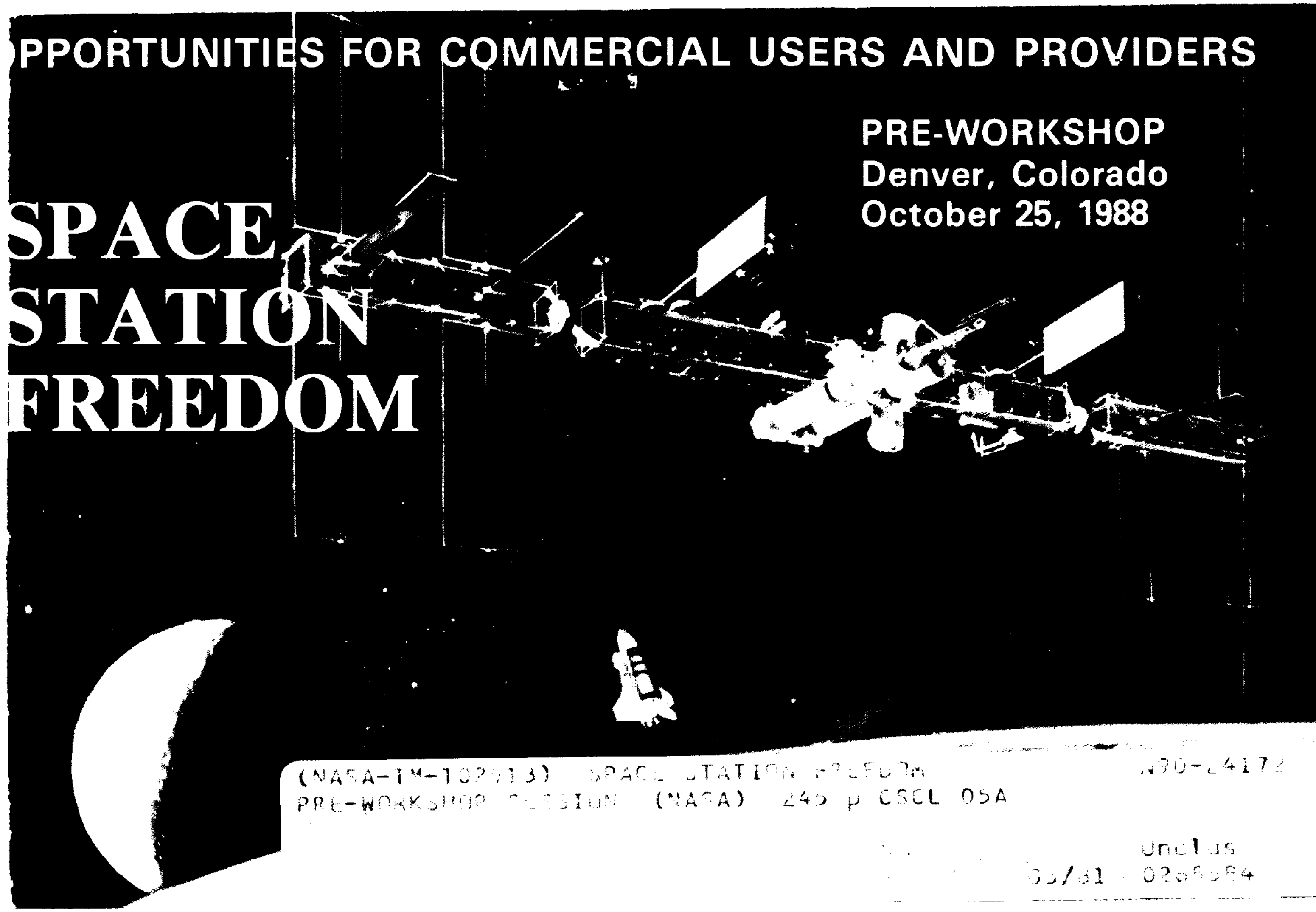


)PPORTUNITIES FOR COMMERCIAL USERS AND PROVIDERS

PRE-WORKSHOP
Denver, Colorado
October 25, 1988

SPACE STATION FREEDOM

FOREWORD

As an adjunct to the Space Station Freedom Workshop held in Denver, Colorado on October 26-28, 1988, a pre-workshop session was held on October 25, 1988 to familiarize U.S. industry with the Commercial Uses of Space Program being implemented by NASA's Office of Commercial Programs. The presentations given during this pre-workshop session, contained herein, provide an overview of Space Station Freedom and commercial space activities directed toward individual involvement and investment in space-related ventures. Any questions or follow-up information relative to these presentations should be directed to:

Office of Commercial Programs

Ms. Arlene Kahn
(202) 453-8722

Mr. Ray Whitten
(202) 453-1890

Office of Space Station

Mr. Richard E. Halpern
(202) 453-1162

Mr. Kevin Barquinero
(202) 453-2638

Boeing/Peat Marwick Commercial Space Group

Mr. Joseph G. Rutter
(202) 479-4240

Mr. Frank DiBello
(202) 467-3088

TABLE OF CONTENTS

SECTION I

COMMERCIAL USES OF SPACE PROGRAM OVERVIEW

Commercial Uses of Space Program Overview

Joseph G. Rutter
Boeing/Peat Marwick
Commercial Space Group

Agenda

Boeing
Peat Marwick

- Background
- National Space Policy
- Commercial Potential of Space
- The Competition
- Support for Industry Involvement

Boeing/Peat Marwick Commercial Space Group

Commercial Space

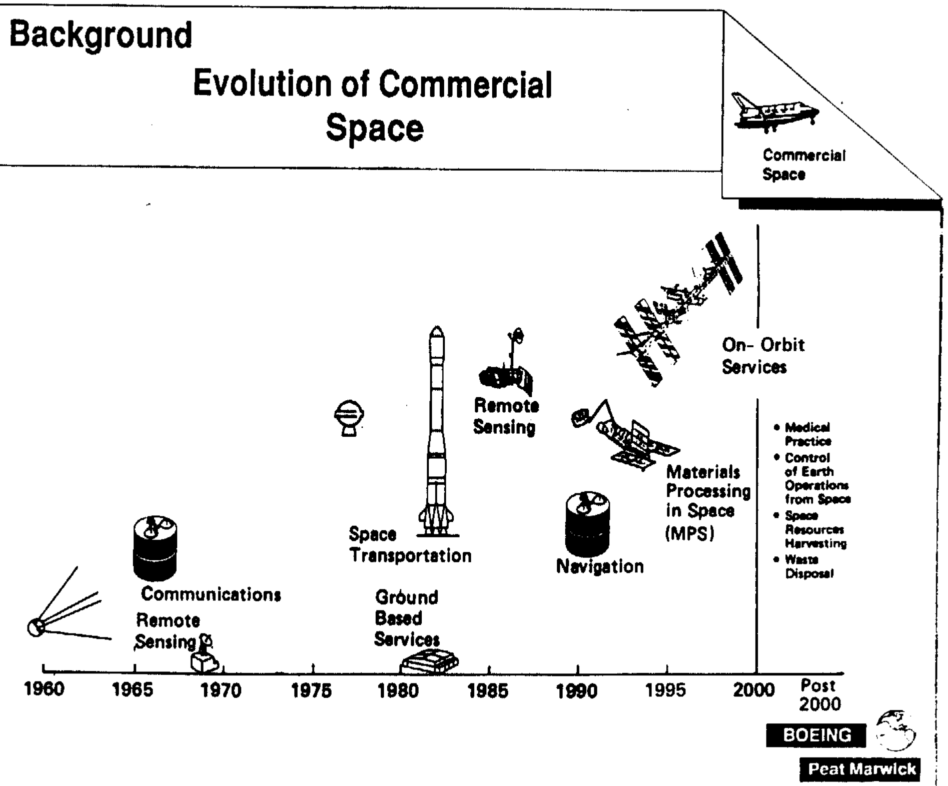
BACKGROUND

BOEING

Peat Marwick

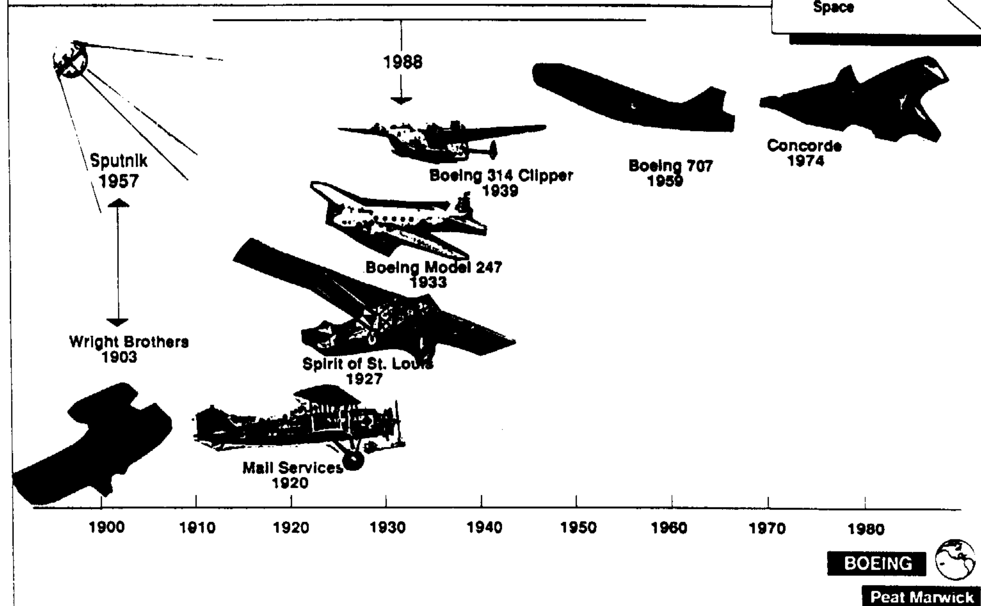
Background

Evolution of Commercial Space



Background

Aviation History Analogue



Space Policy

Commercial Space

- National Aeronautics & Space Act - 1958 (PL 85-568)
- Presidential Directive - National Space Policy - July 4, 1982
- Land Remote Sensing Commercialization Act - July 17, 1984 (PL 98-395)
- Commercial Space Launch Act - October 30, 1984 (PL 98-575)
  - Licensing by Dept. of Transportation
- Executive Order - Facilitating Access to Science & Technology
  - April 10, 1987
- Presidential Directive - National Space Policy - February 11, 1988

BOEING

Peat Marwick

National Aeronautics and Space Act - 1958

Commercial Space

Basic NASA Act

- Section 203 (a)(3)

  "..provide for the widest practicable and appropriate dissemination concerning its activities and the results thereof."

- Section 102 (c) As amended by P.L. 98-361 in 1984:

  "The Congress declares that the general welfare of the United States requires that the National Aeronautics and Space Administration seek and encourage to the maximum extent possible, the fullest commercial use of space."

BOEING

Peat Marwick

National Space Policy - February 11, 1988

Boeing
Peat Marwick

- Acknowledges, for the first time, a separate non-governmental commercial space sector
- Policy Directive States:
  - U.S. Government shall not deter development of commercial sector
  - Government Space sectors shall purchase commercially available space goods and services to fullest extent feasible
  - Commercial sector shall only be regulated/supervised to extent required by law, national security, public safety and international obligations
- Reiterates continuing national committment to Space Station
- Promulgates a fifteen point Commercial Space Initiative

Commercial Space Initiative - February 1988

Boeing
Peat Marwick

Goals

- Promoting a strong commercial presence in space
- Assuring a highway to space
- Building a solid technology and talent base

Key Points

- Provisions for Spacehab
- Facilitate Microgravity Research
- External Tank Availability
- Privatizing Space Station
- Federal Procurement of Remote Sensing Data from Industry
- Insurance Relief for Launch Providers
- Protection of Critical Technologies
- Enhanced Education Opportunities

Boeing/Peat Marwick
Commercial Space Group

Commercial Space

The Commercial Potential Of Space

BOEING

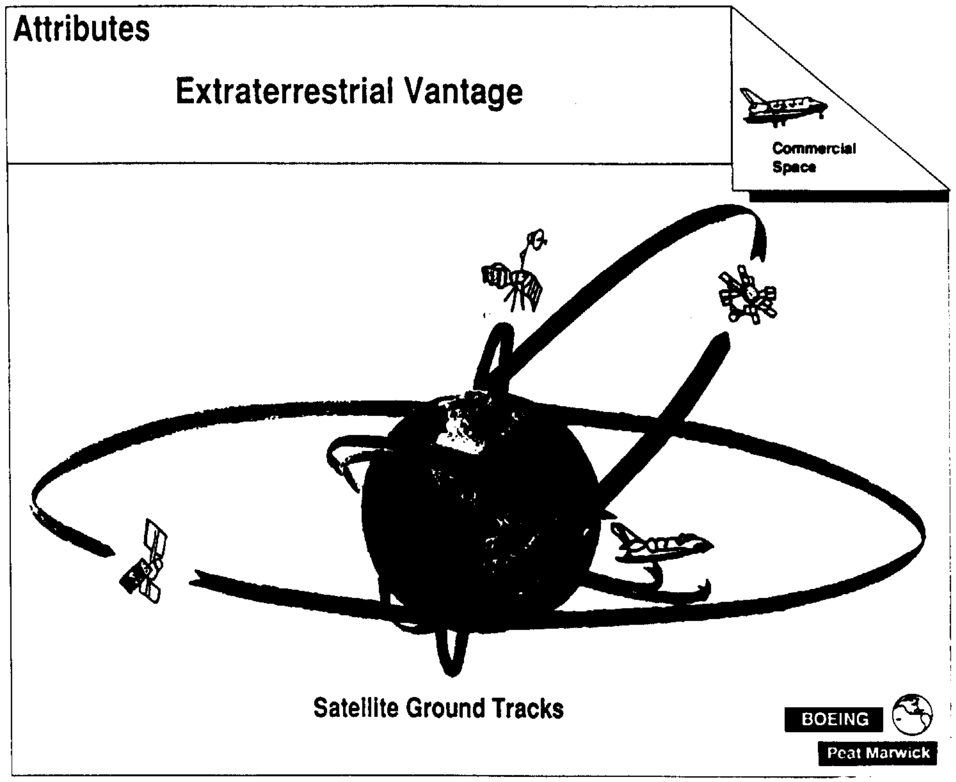
Peat Marwick

Attributes of Space

Commercial Space

- Extraterrestrial Vantage
- Near Earth Environments

BOEING
Peat Marwick


Attributes
Extraterrestrial Vantage
Commercial Space
Satellite Ground Tracks
BOEING
Peat Marwick

Attributes

Extraterrestrial Vantage

Commercial Space

Application	Implication
- Communications	- Worldwide T.V.
- Remote Sensing	- Weather Forecasting
- Navigation	- Cargo Tracking
- Observatories	- Expanded View of Universe

BOEING
Peat Marwick

Applications

Extraterrestrial Vantage

Commercial Space

Remote Sensing

- Meteorology
  - Weather Observation
  - Thermal Balance
  - Storm Warning
- Earth & Ocean Observations
- Search & Rescue

Hurricane Elena
Sept. 2, 1985

BOEING
Peat Marwick

Applications

Commercial Space

Extraterrestrial Vantage

Remote Sensing

- Earth Observations
  - Agriculture and forestry
  - Hydrology
  - Geology
  - Land use planning
  - Cartography
  - Environmental monitoring
  - Regulatory and litigation information

Infrared Image
Crop Rotation

BOEING
Peat Marwick

Attributes

Near Earth Environments

Commercial Space

- Microgravity
- High Vacuum
- Solar Radiation
- Low Temperature Deep Space
- Earth Orbit Atmosphere
- Ionizing Radiation
- Meteoroids/Debris
- Earth's Magnetic Field
- Ionosphere

Microgravity in Orbiter STS 51-D

BOEING

Peat Marwick

Attributes

Near Earth Environments

Applications	Implications
- Materials Processing	- Microspheres
- Tethered Satellites	- Power Generation
- Life Sciences	- Long Term Space Effects on Life

BOEING
Peat Marwick

The Competition

Boeing
Peat Marwick

- Transportation
- Remote Sensing
- Materials Processing

International Space Transportation Comparison
Table IVa

Present	Launch Services			Launch and On-Orbit Services		On-Orbit Services	
	Suborbital Rockets	Expendable Launch Vehicles (ELV)	Expendable Upper Stages	Unmanned Spacecraft	Piloted Spacecraft	Reusable Inter-Orbit Transfer Vehicles	Man Maneuvering Units
U. S.	Loft - 1 Terrier - Black Brant Nike - missile based	Atlas Scout Titan II SLV Delta Atlas-Centaur Titan 34D Titan IV Conestoga II American Rocket Co. E-Prime	PAM TOS IUS		Columbia Discovery Atlantis		MMU
U.S.S.R.	Vertikal	Kosmos (SL-8) Soyuz (SL-4) Vostok (SL-3) Molniya (SL-6) Tsyklon (SL-14) Proton (SL-12,13) Energiya (SL-17)		Progress	• Space Shuttle (Kosmolyet) • Soyuz - TM • Soyuz		
JAPAN	TR - 1100	N - 1, N - 11 H - 1 M - 3S, M -3S11					
CHINA		Long March 2 Long March 3		SETE			

"offers commercial services"

BOEING

Peat Marwick

International Space Transportation Comparison
Table IVb

Present	Launch Services			Launch and On-Orbit Services		On-Orbit Services	
	Suborbital Rockets	Expendable Launch Vehicles (ELV)	Expendable Upper Stages	Unmanned Spacecraft	Piloted Spacecraft	Reusable Inter-Orbit Transfer Vehicles	Man Maneuvering Units
ESA		Ariane 1 - 4				EURECA	
FRANCE							
GERMANY	TEXUS						
BRAZIL	Sonda						
INDIA		SLV - 3 ASLV					

[shaded box] "offers commercial services"

BOEING

Peat Marwick

International Remote Sensing Comparison
Table VIIa

Present	Meterological Satellites	Earth and Ocean Observation	Ground - Based Research	
U. S.	NOAA GOES	LANDSATS 4&5 ERBS	• U-2, CV-990 and Lear Jet • Earth Resources Lab at J. C. Stennis • ARC • Center for Real-time Mapping • ITD Space Remote Sensing Center • TAC	
U.S.S.R.	Meteor 2 Meteor 3 - 1	Kosmos 1500 Kosmos 1602 Kosmos 1766 Kosmos 1869 Kosmos 1870		
FRANCE		SPOT - 1		
JAPAN	GMS. GMS - 2 GMS - 3	MOS - 1		

"offers commercial services"

BOEING

Peat Marwick

International Remote Sensing Comparison
Table VIIb

Present	Meterological Satellites	Earth and Ocean Observation	Ground - Based Research	
ESA	Metosat 1 Metosat 2			
INDIA	Insat - 1 Insat - 1B Insat - 1C	IRS - 1		
BRAZIL				
CHINA				
CANADA				

"offers commercial services"

BOEING
Peat Marwick

International Microgravity Facilities Comparison
Table Ia

Present	Terrestrial Facilities			Suborbital Systems	Orbital Systems			
	Drop tubes/ towers	Labs	Aircraft/ Aerostats		Unmanned Spacecraft	Man-tended Spacecraft	Manned Spacecraft	Space Stations
U. S.	MSFC LeRC JPL	MSFC MMSL	KC-135 Learjet	• [illegible] • Terrier-Black Brant • Nike-missile-based		LDEF	Shuttle Spacelab MSL	
U.S.S.R				Vertikal	Photon KOSMOS 1887	KOSMOS 1443 Class Vehicle	Soyuz Soyuz TM	Salyut 7 MIR
JAPAN			Balloon drops	TR-1100 (MU3S11)*				
CHINA					SETE			
ESA			Procures from NASA			EURECA	Uses Spacelab	
FRANCE	Onera (Paris)							
GERMANY			Dornier 28 Mikroba	Texus		SPAS	Uses Spacelab	

*Theoretically available for sounding rocket

"offers commercial services" (shaded cells)

BOEING
Peat Marwick

International Microgravity Facilities Comparison
Table Ib

Present	Terrestrial Facilities			Suborbital Systems	Orbital Systems			
	Drop tubes/ towers	Labs	Aircraft/ Aerostats		Unmanned Spacecraft	Man-tended Spacecraft	Manned Spacecraft	Space Stations
BRAZIL				Sonda				
INDIA				Rohini RH 300				
DENMARK			Gulfstream III					
SWEDEN				Maser				
NETHER-LANDS			Hawker Hunter Metro turbo-prop					
CANADA								
AUSTRALIA								

"offers commercial services"

BOEING
Peat Marwick

Support for Industry Involvement

Available Support Avenues

Boeing
Peat Marwick

- NASA Cooperative Agreements and Facilities
- Centers for the Commercial Development of Space (CCDS)
- Boeing/Peat Marwick Commercial Uses of Space Group

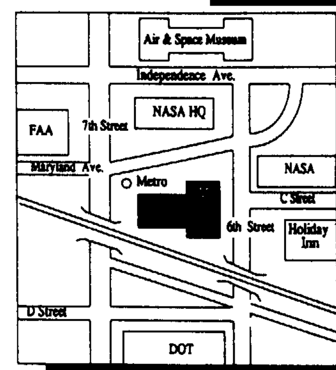
Boeing/Peat Marwick
Commercial Space Group

Commercial Space

NASA Contract
NASW-4220

Services to Support
Commercial Uses
of Space

- Commercial Development
- Commercial Agreements
- Space Station
  Commercial Requirements



Capital Gallery Building
600 Maryland Avenue, S.W.
Suite 455
Washington, D.C. 20024
(202) 479-4240

BOEING
Peat Marwick

SERVICES TO SUPPORT THE COMMERCIAL USES OF SPACE

Boeing
Peat Marwick

- **Scope**

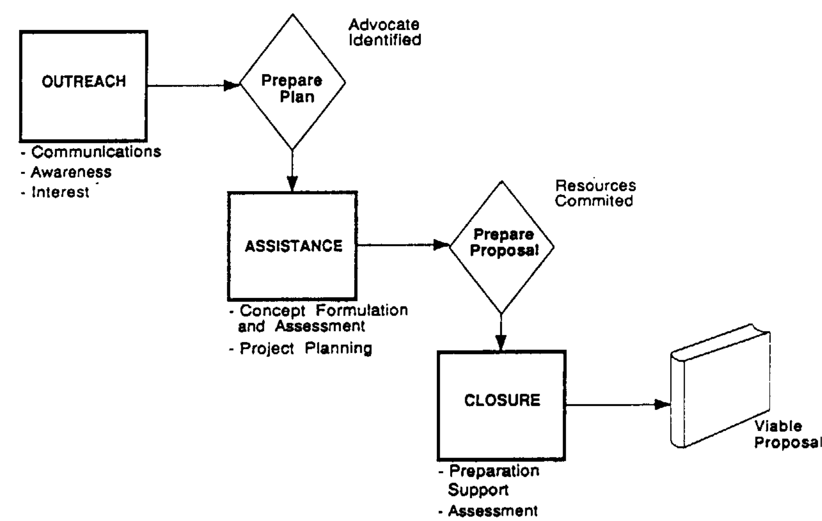
  Develop and implement a program to stimulate and sustain domestic commercial interest and investment in commercially oriented space-related R&D activities.

- **Goal**

  Receipt by NASA of credible proposals:
  - private investment capital
  - agreement benefitting both NASA and private firms

THREE PHASE APPROACH

Boeing
Peat Marwick

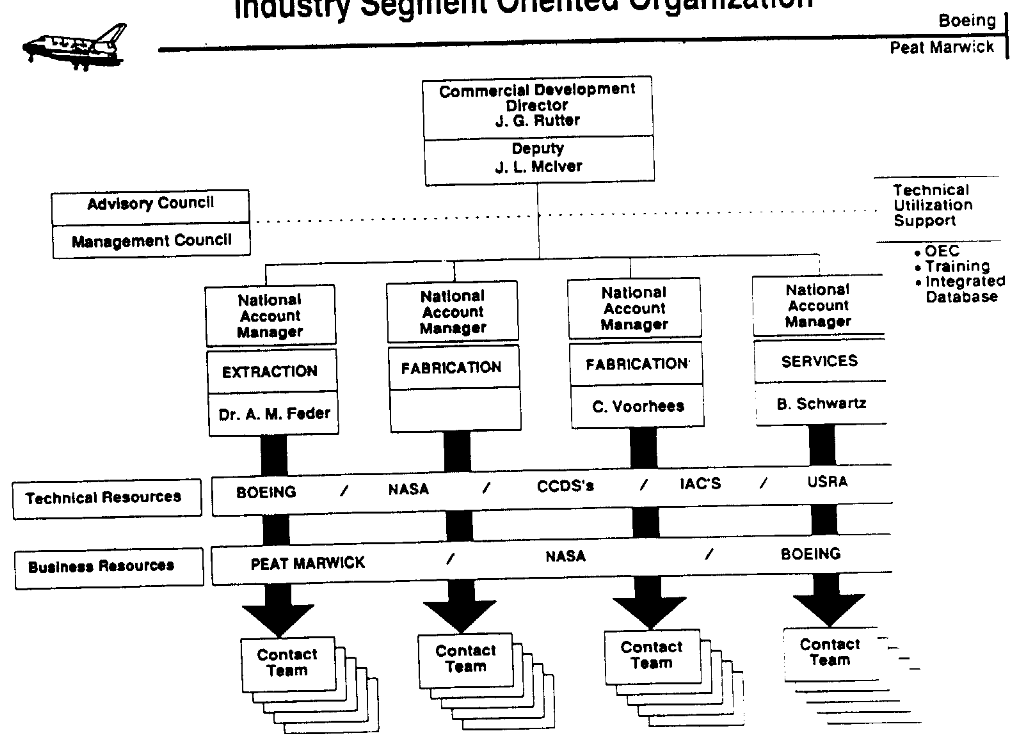


ALLOCATION OF STANDARD INDUSTRIAL CLASSIFICATION CODES TO MAJOR ECONOMIC ACTIVITIES

Boeing
Peat Marwick

EXTRACTION		FABRICATION		SERVICES	
DIV.	SECTOR	DIV.	SECTOR	DIV.	SECTOR
A	Agriculture, Forestry, & Fishing	C	Construction	E	Transportation, Communications, Sanitary Services
B	Mining	D	Manufacturing	F	Wholesale Trade
				G	Retail Trade
				H	Finance, Insurance, & Real Estate
				I	Services (Health, Business, Legal, Repair, etc.)

National Account Manager
Industry Segment Oriented Organization



To Be There Tomorrow....
Act NOW!

Commercial Space

"Our willingness to accept the challenge of space will reflect whether America's men and women today have the same bold vision, the same courage and indomitable spirit that made us a great nation"

Ronald Reagan

BOEING

Peat Marwick

SECTION II

SPACE STATION FREEDOM PROGRAM OVERVIEW

NASA
National Aeronautics and
Space Administration

SPACE STATION FREEDOM PROGRAM OVERVIEW

Presented to the
Space Station Freedom Workshop

OCTOBER 25, 1988

RICHARD HALPERN
Utilization and Operations Division
Office of Space Station

1984 STATE OF THE UNION

"America has always been greatest when we dared to be great. We can reach for greatness again.

We can follow our dreams to distant stars, living and working in space for peaceful, economic and scientific gain. Tonight, I am directing NASA to develop a permanently manned space station and to do it within a decade.

A space station will permit quantum leaps in our research in science, communications and in metals and life-saving medicines which can be manufactured only in space.

We want our friends to help us meet these challenges and share in their benefits.

NASA will invite other countries to participate so we can strengthen peace, build prosperity and expand freedom for all who share our goals."

President Ronald Reagan

[illegible] 1984

NATIONAL SPACE POLICY

- On January 5, 1988, President Reagan approved a revised National Space Policy which sets the direction of U.S. efforts in space
- Leadership is a fundamental objective guiding U.S. space activities
- The policy reaffirms the national commitment to the Space Station

An objective of U.S. civil space activities is the establishment of a permanently manned presence in space

- Space Station contributes to other overall goals of U.S. space activities:
  - expansion of human presence and activity beyond Earth orbit into the solar system
  - obtaining scientific and technological benefits
  - encouragement of U.S. private sector investment in space and related activities
  - promotion of international cooperation in space

OSSTT 24

SPACE STATION PROGRAM OBJECTIVES

- Develop a permanently manned Space Station by the mid 1990's
- Provide useful and affordable capabilities
- Enhance space science and applications
- Help realize the commercial potential of space
- Implement international agreements

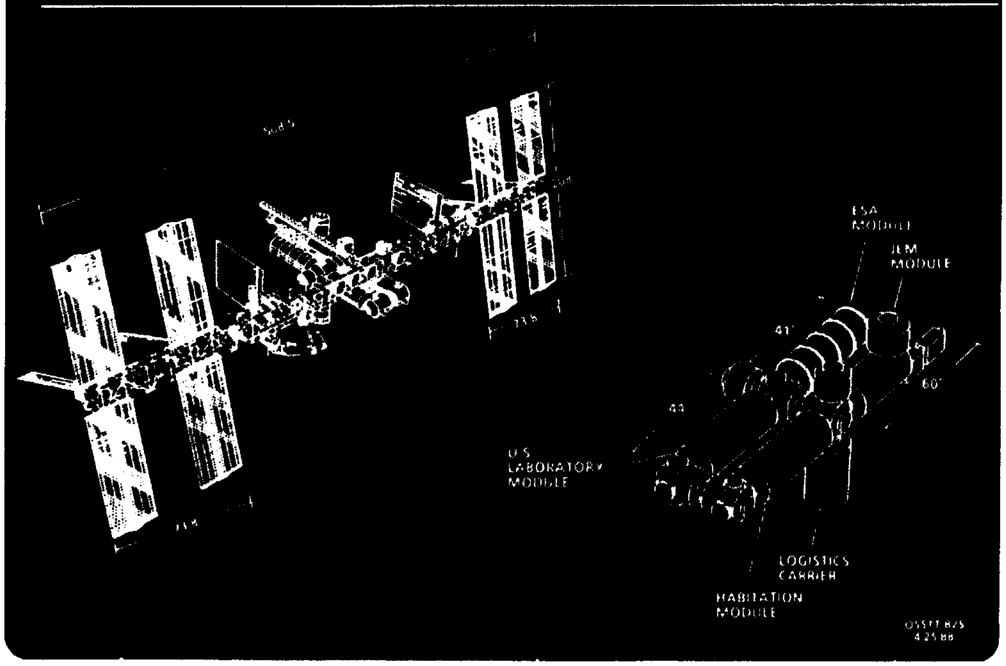
- Design for evolution
- Push automation and robotics technologies (design in and scar)
- Provide early man-tended capability
- Blend manned and unmanned systems and capabilities

SPACE STATION FREEDOM PLATFORMS

- The Space Station Freedom will consist of unmanned platforms and a manned base
- Initially, platforms will be in polar orbit. Later, Freedom's enhanced capability configuration might include coorbiting platform
- NASA made commitment to Congress that platforms are an integral part of the Space Station Freedom
- Goddard work package includes definition, development, utilization and servicing of Freedom's platforms
- European Space Agency will also develop a station polar platform
- In January, 1988 NASA released an Announcement of Opportunity (AO) for scientific instruments onboard the polar platforms
- Platforms will play key role in Freedom's evolution

PLATFORMS CONTRIBUTE SIGNIFICANTLY TO SPACE STATION FREEDOM'S CAPABILITY

BASELINE CONFIGURATION DIMENSIONS



SPACE STATION RESEARCH OPPORTUNITIES

LIFE SCIENCES

- Space Biology
- Space Medicine
- Exobiology

ASTRONOMICAL SCIENCES

- Plasma Physics
- Solar Physics
- Astrometric Observations

MATERIALS SCIENCES

- Electronic Materials
- Biotechnology
- Combustion Science
- Metal, Alloy, Glass and Ceramics Processing

EARTH SYSTEM SCIENCES

- Global Hydrology
- Global Biogeochemistry
- Climatology
- Geophysics

OSSTT 16A

LIFE SCIENCES RESEARCH ON SPACE STATION

GOAL: To advance knowledge of the fundamental behavior of living cells; to guarantee the health and safety of astronauts living and working in space; and to understand the evolution of life in the universe.

- **SPACE BIOLOGY**
  - — Gravitational Biology
  - — Developmental Biology
- **SPACE MEDICINE**
  - — Sensorimotor Integration
  - — Bone and Mineral Metabolism
  - — Cardiovascular and Pulmonary Functions
  - — Muscle Atrophy, Anemia, Nutrition, Behavior
- **EXOBIOLOGY AND BIOSPHERICS**
  - — Cosmic Evolution of Life
  - — Global Study of Life Processes

MATERIALS SCIENCE RESEARCH ON SPACE STATION

GOAL: Use the microgravity environment of space to advance knowledge of fundamental science and apply the knowledge gained to the development of advanced processes and technologies.

FIELDS OF STUDY:

- Electronic Materials Research
- Biotechnology
- Combustion Science
- Fluid Dynamics and Mass Transport
- Metals and Alloys
- Glasses and Ceramics

OSSTT-16H
NASA HQ SF Rev. 1-6-88

ASTRONOMICAL RESEARCH ON SPACE STATION

GOAL: Capitalize on the unique attributes of the Space Station which enhance astronomical research, such as:

— Long (Multi-Decade) Observation Times
— Rapid Response Research
— Repetitive Access to Payloads for Resupply and Repair

• **ASTROPHYSICS**
  — Origin and Composition of Cosmic Rays
  — Study of Galaxy Clusters

• **SOLAR AND PLANETARY PHYSICS**
  — Search for Other Planetary Systems
  — Capture and Analysis of Cosmic Dust
  — Study of Solar-Terrestrial Interactions

• **SPACE PLASMA PHYSICS**
  — Study of the Space Plasma Environment
  — Study of Plasma Interactions with Space Station

EARTH SCIENCES RESEARCH ON SPACE STATION

GOAL: To investigate the Earth as a system, from its interior through the inner magnetospheric boundary.

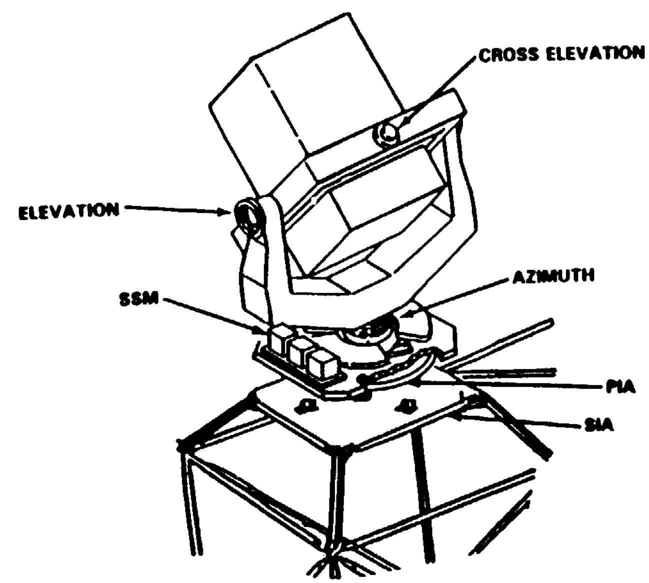
- **GEODYNAMICS**
  - Crustal Dynamics
  - Gravitational and Magnetic Fields
- **LAND PROCESSES**
  - Terrestrial Ecosystems
  - Hydrology
  - Geology
  - Remote Sensing
- **OCEANOGRAPHY**
  - Ocean Topography
  - Ice Formations
- **ATMOSPHERIC DYNAMICS AND RADIATION**
  - Global Climate Studies
  - Meteorology
  - Aerology

OSSTT-16J

MECHANICAL INTERFACE - EXTERNAL ATTACH POINTS

- Four utility parts available on truss
  - -- Utilities available: power, command and data, video and high rate data, thermal control, GN&C data, etc
- Two sets of payload attach equipment provided, including:
  - -- Station interface adapters
  - -- Payload interface adapters
  - -- Deck carriers
  - -- Multiple payload adapters
  - -- System support module
- Payload Pointing System
  - -- Three axis pointing
  - -- CG Yoke design
  - -- Stability: thirty arc seconds peak-to-peak
- Additional small attached payload accommodations are under consideration

ATTACHED PAYLOAD ON PAYLOAD POINTING SYSTEM



POWER SYSTEM

- Total powe. ıvailable - 75kw
- User power available - 45kw
- Main bus - 440 volts, 20KHz, single phase
- Direct user interface - 208 volts, 20KHz, single phase
- Station - provided converters at each payload
  - -- 120/208 volts, 60 hz, single phase
  - -- 28 volts dc
  - -- User charged for conversion losses
- Maximum available at one double rack
  - -- 15kw at six special double racks
  - -- 3kw at all other double racks
- Maximum available at one external attachment point
  - -- 10kw for payload
  - -- 2 kw for Station-provided subsystems

THERMAL CONTROL SYSTEM

- Heat rejection capacity for user - 45kw
- Attached payload interface - cold plates
- Rack interface
  - -- 20% of racks - cold plates
  - -- 80% of racks - air cooling
    - Via rack plenums (no ducts)
    - Air temp: 50-110° F
    - Air flow: 25-210 CFM

DATA MANAGEMENT SYSTEM

- Provides communication path transparent to users
- Allows remote control and monitoring of payloads
- Provides common crew interfaces
- Employs local areà networks and local buses
- Data link formats
  - -- Serial links
  - -- International standards will be used
  - -- Low rate example - RS 232 at 9600 band
  - -- High rate example - MS 1553 at 1 Mbs
- Maximum data rates
  - -- At attached payload ports: 10 Mbs
  - -- At racks: 1-100 Mbs, depending on rack

NASA
Space Station

HIGH RATE DATA AND VIDEO

- Maximum total data rate from manned base: 300Mbs

- High rate data handled separately from DMS system
  - -- Via Command and Tracking (C&T) system

- Maximum digital data rates
  - -- At attached payload ports: 100 Mbs
  - -- At racks: 150 Mbs
  - -- Interface: Space to ground signal processor

- Analog video
  - -- Digitization, compression, and frame grabbing provided at the signal processor
  - -- Interface format: component video

OPERATIONS CHARACTERISTICS MANNED BASE SPACE OPERATIONS (Continued)

ON-BOARD ACTIVITIES (Continued)

- Crew Support Concept
  - -- Eight Person crew at Phase 1 completion
  - -- Two four -person shifts per day
  - -- Nine hour workday, six days per week
  - -- Approximately three people per shift available for users
  - -- EVA: eighteen hours/week, shared between users and station

PAYLOAD TRANSPORTATION ACCOMMODATIONS

- Pressurized Logistics Carriers
  - -- Both rack and non-rack accommodations available
  - -- Refrigerator or freezer provided
  - -- Life sciences accommodations in a controlled environment
- Unpressurized Logistics Carriers
  - -- Both rack and non-rack accommodations available
  - -- Accommodations for dry cargo and fluids
- Deck Carriers
  - -- For use with external attached payloads
- Upmass available to all users
  - -- During Phase 1 construction: ~77,000 lbs
  - -- After Phase 1 completion: ~50,000 lbs/year

National Aeronautics and Space Administration

POLAR PLATFORM

- Orbit parameters
  - -- Altitude: 824km
  - -- Inclination: 98.7 deg
- Attitude
  - -- Orientation: LVLH
  - -- Stability: .002 deg
- Payload capacity
  - -- 3000 kgm (Titan IV or ASRM STS)
- Power
  - -- 2.5kw total
  - -- 1.1kw for users (208v, 20KHz)
- Data rate
  - -- 300 Mbps
  - -- S-band and Ku-band over TDRSS
- Thermal Control
  - -- Dissipation for user: 1.1 kw
  - -- Cold plates and radiators

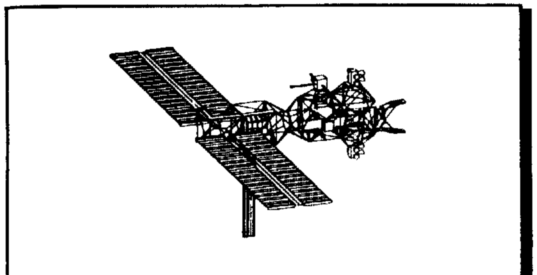
SPACE STATION ASSEMBLY SEQUENCE

Year	FLIGHT #		Elements	Milestone
1995	1	MB-1	18 75 PV MODULE, STBD TRUSS, ALPHA JOINT ERECTOR SET, AVIONICS, TANK FARM, WATER ELECTROLYSIS, RCS MODULES (2), UNPRESS DOCK ADAPTER, S-BAND ANTENNA	
	2	MB-2	AFT STBD NODE, STBD TCS W-9 RAD PANELS, FTS AND SHELTER, STINGER RESISTOJET, TDRSS ANTENNA, TANK FARM, PRESS. DOCKING ADAPTER, CMG'S (6)	
	3	MB 3	AFT PORT NODE, MSC PHASE 1, TANK FARM, STBD RADIATOR PANELS, PRESS. DOCKING ADAPTER, FMAD, STANDARD AIRLOCK	
	4	MB-4	U.S. LAB MODULE	MAN-TENDED
		P-1	U.S. POLAR PLATFORM	
1996	5	MB-5	PORT INBD PV MODULE, ALPHA JOINT, PORT TRUSS, RCS MODULES (2), PORT RADIATOR, STBD RADIATOR PANELS, TANK FARM, SSEMU VERIFICATION UNIT	
	6	OF-1	PRESS. LOG MOD, MODULE OUTFITTING	
	7	UOF-1	ATTACHED PAYLOADS, MICROGRAVITY LAB OUTFITTING, MAN-TENDED EXPERIMENT OPERATIONS* (UTILIZING EXTENDED DURATION ORBITER)	
	8	MB-6	SSRMS-2, HB AIRLOCK, ATTACH P L AND EQUIPMENT	
	9	MB-7	U.S. HAB MODULE	
	10	MB-8	FORWARD NODES, CUPOLAS (2)	
	11	MB-9	CREW (4), LOGISTICS MODULES, SSEMU'S (4)	PERMANENTLY MANNED
1997	12	MB-10	STBD, PORT OUTBOARD PV MODULES	
	13	L-1	LOGISTICS MODULES, SPDM	
		ARIANE	ESA POLAR PLATFORM	
	14	MB-11	JEM MODULE, JEM EXPOSED FACILITY #1, CREW (8)	
	15	L-2	LOGISTICS MODULES, ATTACH P/L AND EQUIPMENT	
	16	MB-12	ESA MODULE	
	17	L-3	LOGISTICS MODULES, MMD PHASE 1	
	18	MB-13	JEM EXPOSED FACILITY #2, JEM ELM, JEM LOGISTICS AND PAYLOADS	
	19	L-4	LOGISTICS MODULES	
1998	20	OF-2	PRESS. LOG MOD, MODULE OUTFITTING	ASSEMBLY COMPLETE
		ARIANE	ESA MTFF	

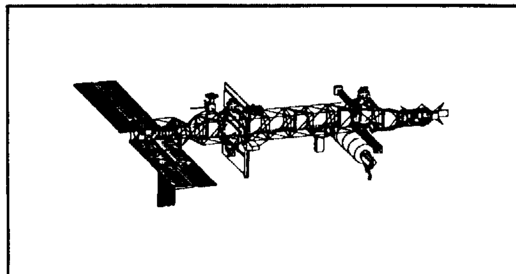
* IN THE EVENT FULL MISSION OBJECTIVES CAN NOT BE ACHIEVED ON UOF 1, A SECOND EXTENDED DURATION ORBITER FLIGHT WILL BE ADDED

OSSTT 9?T
05 10 88

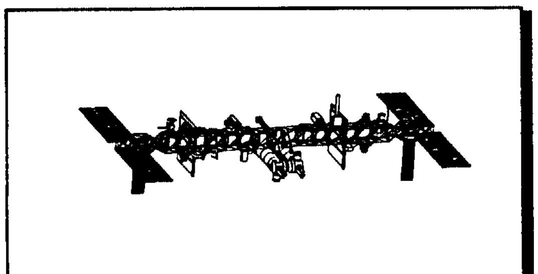
MILESTONE FLIGHTS



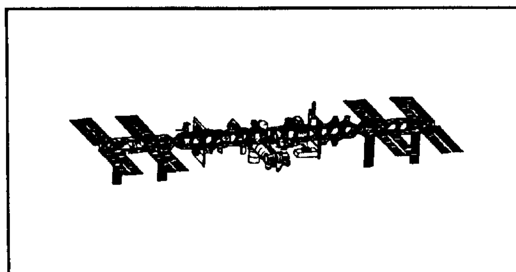
First Element Launch



Man-Tended Capability



Permanently Manned Capability



Assembly Complete

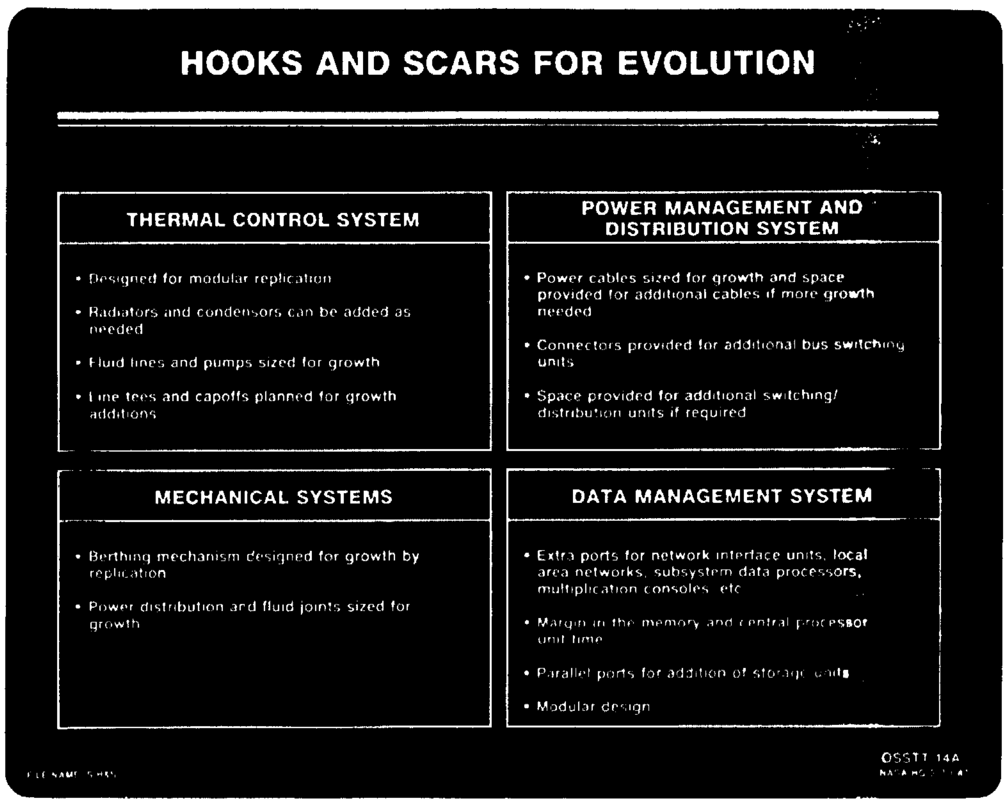
SPACE STATION DEVELOPMENT SCHEDULE

Program Review Requirements	2nd Qtr, 1988
Preliminary Design Reviews	1st Qtr, 1990 - 1st Qtr, 1991*
Critical Design Reviews	2nd Qtr, 1991 - 2nd Qtr, 1993*
First Element Launch	1st Qtr, 1995
Polar Platform Launch	4th Qtr, 1995
Man-Tended Capability	4th Qtr, 1995
Utilization and Outfitting Flight (EDO)	2nd Qtr, 1996
Permanently Manned Capability	4th Qtr, 1996
Assembly Complete	1st Qtr, 1998

* May change during current reassessment

FILE NAME S SSDevSch

OSSTT 46C
NASA HQ Rev 8 1 88


HOOKS AND SCARS FOR EVOLUTION
THERMAL CONTROL SYSTEM
• Designed for modular replication
• Radiators and condensors can be added as needed
• Fluid lines and pumps sized for growth
• Line tees and capoffs planned for growth additions
POWER MANAGEMENT AND DISTRIBUTION SYSTEM
• Power cables sized for growth and space provided for additional cables if more growth needed
• Connectors provided for additional bus switching units
• Space provided for additional switching/distribution units if required
MECHANICAL SYSTEMS
• Berthing mechanism designed for growth by replication
• Power distribution and fluid joints sized for growth
DATA MANAGEMENT SYSTEM
• Extra ports for network interface units, local area networks, subsystem data processors, multiplication consoles, etc
• Margin in the memory and central processor unit time
• Parallel ports for addition of storage units
• Modular design
OSSTT 14A

PROGRAM BUDGET
(Real Year $ in Millions)

	PRIOR	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993
DEFINITION	595.0	0	0	0	0	0
DEVELOPMENT	549.5	842	2035	2756	3243	3075
FLIGHT TELEROBOTIC SERVICER	51.5	46	45	45	50	45
TRANSITION DEFINITION	4.0	12	25	32	42	44
OPERATIONS	0	0	25	80	199	546
TOTAL	1200.0	900	2130	2913	3534	3710

NOTE Run-out budget does not yet include impacts of FY 89 total budget reduction or FY 89 increase to FTS

OSSTT 67
9 2 88

KEY PROGRAM CHALLENGES

- Design for permanence, maintainability and evolution
- Build to cost and schedule
- Match Station assembly and operations design with transportation capabilities
- Manage systems engineering/integration
- Establish effective technical management and information system (TMIS)
- Incorporate new technologies, balancing cost, schedule and technical risks
- Understand and incorporate operational costs in planning and design
- Secure commercial participation in Station development
- Orchestrate international dimension
- Maintain customer focus when time, money and engineering begin to pinch
- Assemble and checkout on-orbit

SECTION III

ATTRIBUTES OF SPACE

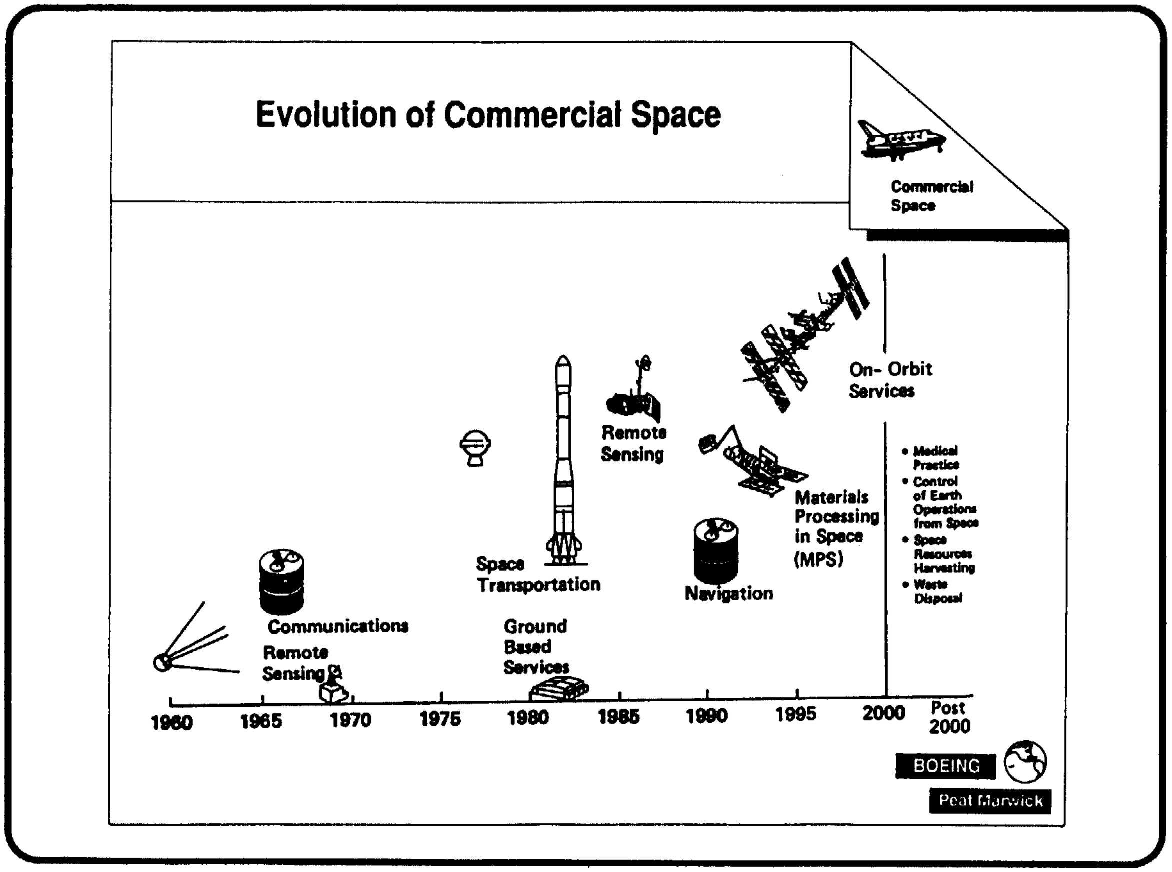
Attributes of Space

Commercial Space

Introduction

Dr. E. A. Brown
Boeing Aerospace Operations

BOEING
Peat Marwick


Evolution of Commercial Space
Commercial Space
Communications
Remote Sensing
Space Transportation
Ground Based Services
Remote Sensing
Navigation
Materials Processing in Space (MPS)
On- Orbit Services
• Medical Practice
• Control of Earth Operations from Space
• Space Resources Harvesting
• Waste Disposal
1960
1965
1970
1975
1980
1985
1990
1995
2000
Post 2000
BOEING
Peat Marwick

Attributes of Space

Commercial Space

A unique environment

- An opportunity for commercialization
- A challenge to the designer

BOEING
Peat Marwick

Attributes and Environments of Space

This chart shows the nine attributes and environments of space at low earth orbit altitudes. Each is described and discussed in more detail in the remainder of the document.

Attributes and Environments of Space

Commercial Space

- Extraterrestrial vantage point
- Microgravity
- Solar radiation - high/low temperature
- High vacuum
- Residual atmosphere
- Ionosphere
- Geomagnetic field
- Ionizing radiation
- Meteoroids/debris

BOEING
Peat Marwick

Attributes / Environments

Commercial Space

1. Extraterrestrial Vantage Point

BOEING

Peat Marwick

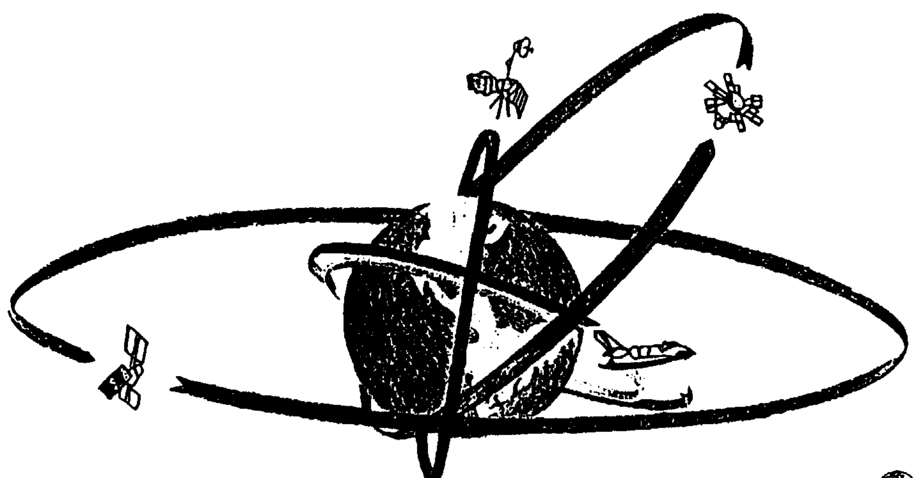
Extraterrestrial Vantage Point

Spacecraft in earth orbit provide a useful extraterrestrial vantage point both for downward earth observation and outward astronomical observation.

Satellite launches from NASA'S Kennedy Space Center are nominally at inclinations of 28.5° and 57° to the equator and are not suitable for polar observation. Launches are made into polar orbit from Vandenberg Air Force Base. These polar orbits include sunsynchronous (dawn/dusk) orbits that permit continuous daylight observation. Molnyia orbits are highly eccentric ellipses that provide extended viewing periods near apogee (the highest point). Geosynchronous orbits at a height of 6.6 earth radii provide continuous coverage of a global hemisphere, but provide poor viewing of polar regions.

Extraterrestrial Vantage Point

Commercial Space



BOEING

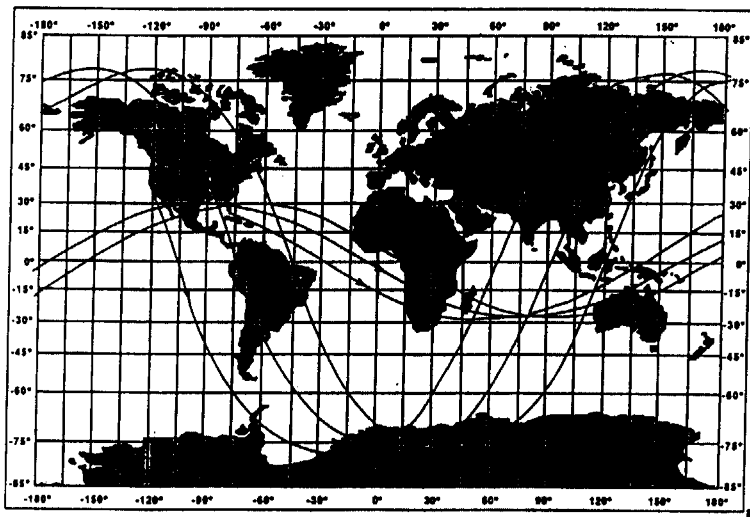
Peat Marwick

Satellite Ground Tracks

The chart shows the ground projections for two orbits. One is the typical ground track coverage of a low inclination (~30°), low altitude satellite which allows passage over the same area every seven orbits (~10.5 hours). The other ground track is for a near polar sunsynchonous satellite in a high altitude circular orbit (~1690 km altitude, 102° inclination) it provides coverage of the same area every six orbits (~12 hours).

Satellite Ground Tracks

Commercial Space



BOEING

Peat Marwick

ORIGINAL PAGE IS
OF POOR QUALITY

Uses of Extraterrestrial Vantage Point

The chart lists the four major uses of the earth orbit vantage point. An example of each in given in the next four charts.

Use of Extraterrestrial Vantage Point

Commercial Space

- Communication relay node
- Earth remote sensing
- Solar/stellar observations
- Navigation node

BOEING
Peat Marwick

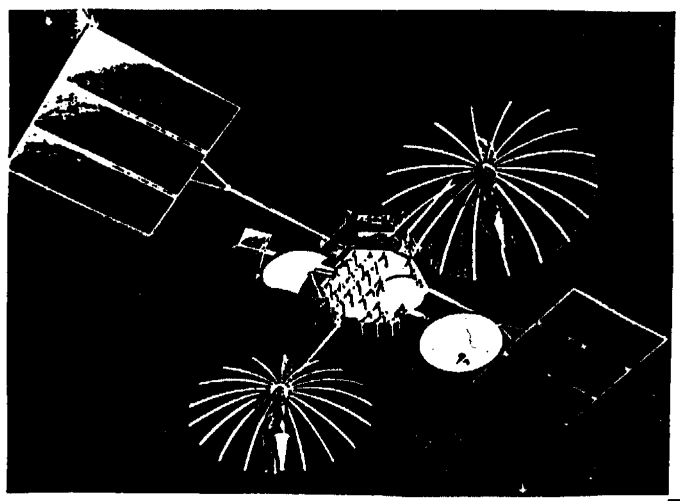
Telemetry Data Relay System (TDRS)

Many low-altitude satellites are not in radio contact with friendly ground stations for most of their orbits. The Telemetry Data Relay System (TDRS) satellites at geosynchronous locations provided global coverage of satellite positions.

The satellites have a communicaiton system which can relay mission commands and telemetry data between all satellite locations and continental U.S. ground stations continuously.

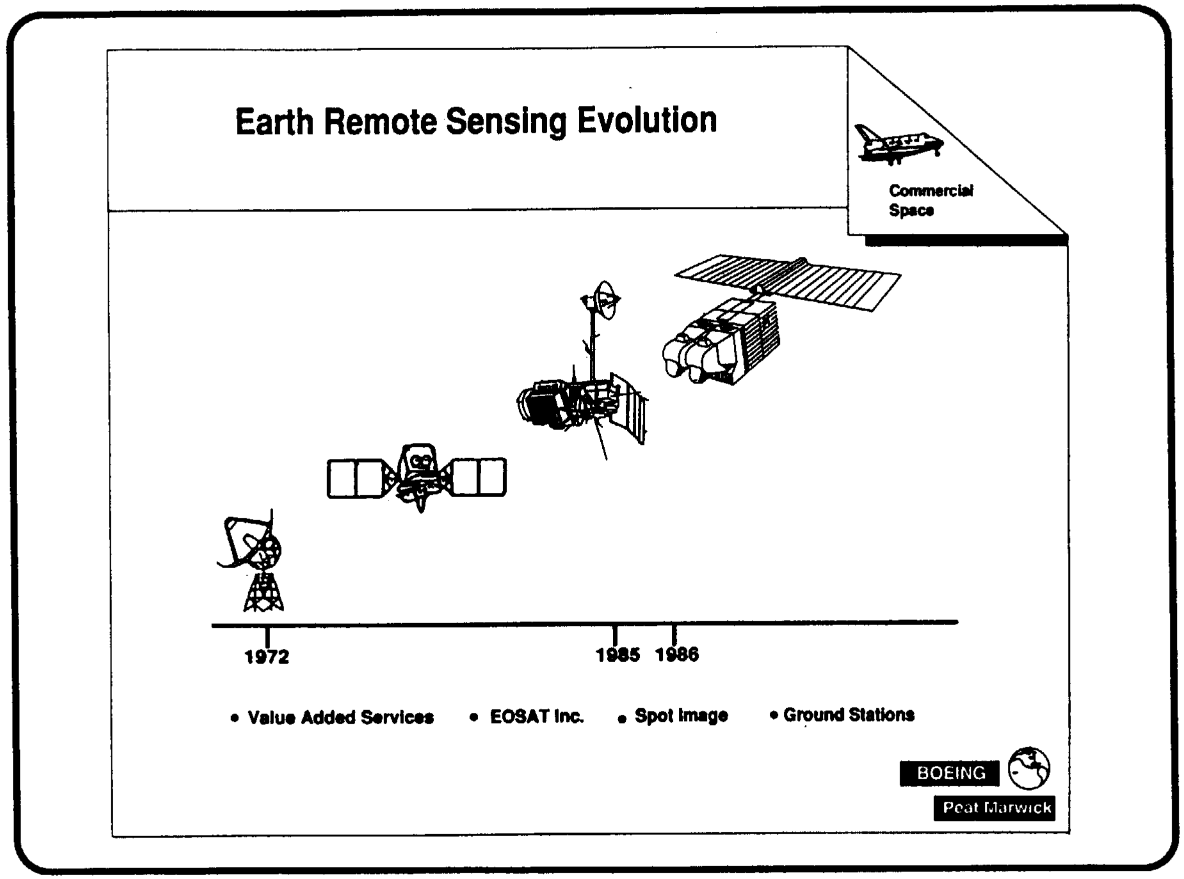
Tracking & Data Relay Satellite (TDRS)

Commercial Space



BOEING

Peat Marwick


Earth Remote Sensing Evolution
Commercial Space
1972
1985
1986
• Value Added Services
• EOSAT Inc.
• Spot Image
• Ground Stations
BOEING
Peat Marwick

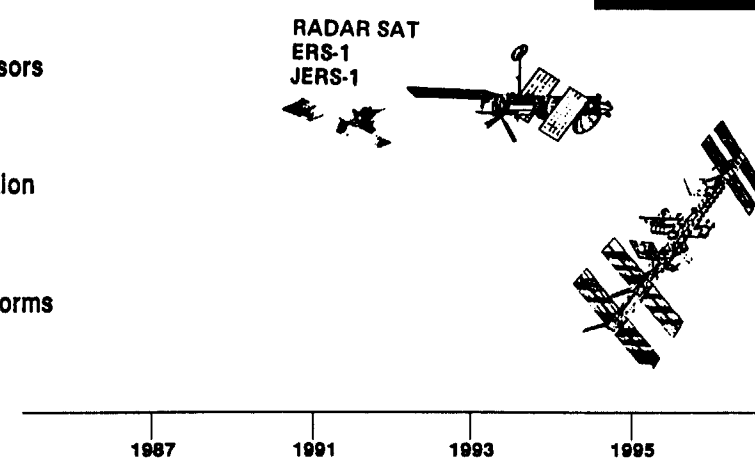
Earth Remote Sensing Evolution

The chart shows the evolution, past and predicted, in earth remote sensing by satellites. It shows the development of satellite ground stations in the 1970's, the United States Landsat Earth Resources satellites, and the recently launched French SPOT satellite. Predicted for the 1990's are synthetic aperture radar satellites and large platforms typified by the proposed NASA Space Station.

Earth Remote Sensing Evolution

Commercial Space

- Radar Sensors
- Space Station
- Large Platforms



BOEING
Peat Marwick

Civilian Earth Remote Sensing Missions

Commercial Space

- Meteorological
- Earth resources
  - Agriculture and forestry
  - Hydrology
  - Geology
  - Land use mapping and planning
  - Environmental monitoring
  - Marine and ocean resources
- Search and rescue

BOEING

Peat Marwick

Hubble Space Telescope

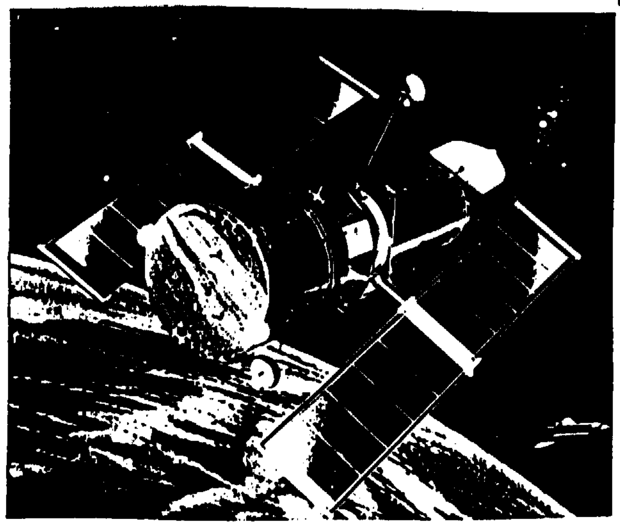
This viewfoil depicts an artist's concept of the fully deployed multipurpose Hubble Space Telescope with the Shuttle nearby. The telescope has a TV type recording system with much more sensitivity and dynamic range than photographic films and is capable of observing celestial sources 50 times fainter than the most powerful telescopes on the ground.

The telescope system will enable Man to piece together much more of the puzzle of the universe: how it began, how it grew, how it is changing, and how those changes affect Earth. Its unique capability for sharply defined imagery without atmospheric interference allows scientists to gaze seven times farther into space than ever before, possibly to the edges of the visible universe.

The telescope will be remotely operated by scientists on the ground through a television-type pointing and recording system. Several optical sensors, located in the instrument bay behind the primary mirror, share the concentrated light collected from celestial sources. The instruments are modular so that modifications, repairs, or replacements can be performed by astronauts.

Hubble Telescope

Commercial
Space



BOEING

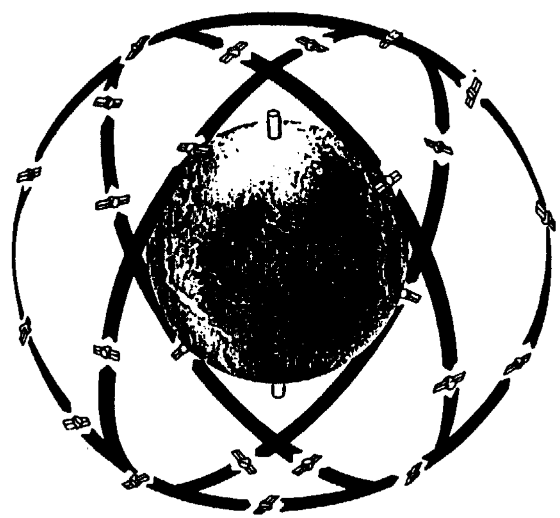
Peat Marwick

Navstar Satellite Navigation System

The U.S. Air Force is planning to establish a network of 18 Navstar Satellites for surface navigation. The satellites will be in three separate polar orbits (6 per orbit) at an altitude of 11,000 miles. From these orbits they will beam radio signals continuously to allow any one on the surface of the earth with a radio to determine his position accurately to within tens of feet.

Navstar Satellite Navigation System

Commercial Space



BOEING

Peat Marwick

Attributes / Environments

Commercial Space

2. Microgravity

BOEING

Peat Marwick

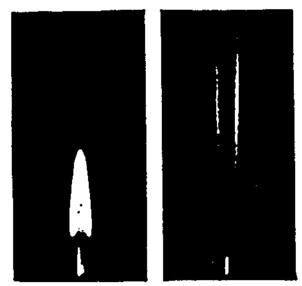
Microgravity

Microgravity conditions in spacecraft create unique opportunities for experiments. All objects in orbit are in free fall and have no apparent weight. There are no convection or buoyancy effects in gases or liquids. The use of small thrusters to control the attitude and position of a satellite introduces effective gravitational forces. On manned missions there will be somewhat more gravity due to astronaut movement.

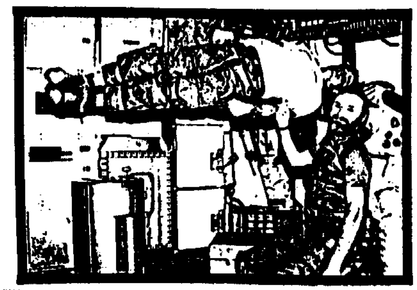
In the picture astronauts Carr and Pogue demonstrate superhuman strength in their pose. This weightless freedom actually inhibits astronaut performance for some tasks requiring application of external forces. Candle flames demonstrate the lack of air convection in a weightless atmosphere where hot combustion gases are not driven upward by heavier cold gas below. Such lack of convection and buoyant separation allows growth of much larger and more uniform crystals such as mercuric iodide shown here.

Microgravity

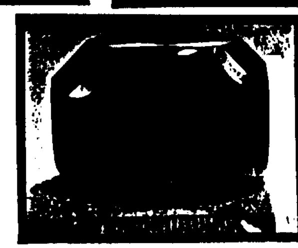
Commercial Space



1g 0g
Physical/Chemical Processes



Near-Weightless



Material Processes

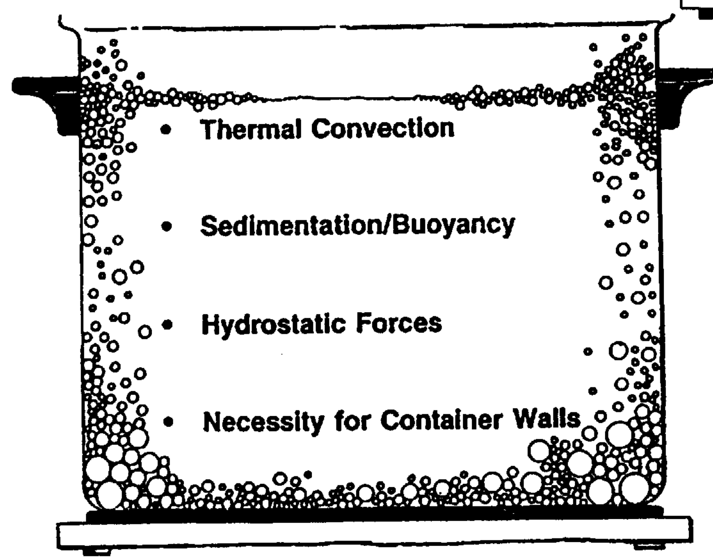
BOEING
Peat Marwick

Physical Processes Affected by Microgravity

Microgravity results in the weakening of natural phenomena such as convection, sedimentation, bouyancy, hydrostatic pressure, and the necessity for container walls. The removal of these phenomena has a significant impact on many aspects of the processing of materials and on scientific research in areas such as studies of combustion and fluid .transport phenomena.

There are large uncertainties in the current understanding of microgravity phenomena and a strong research foundation must be built for commerical applications.

Physical Processes Affected By Microgravity



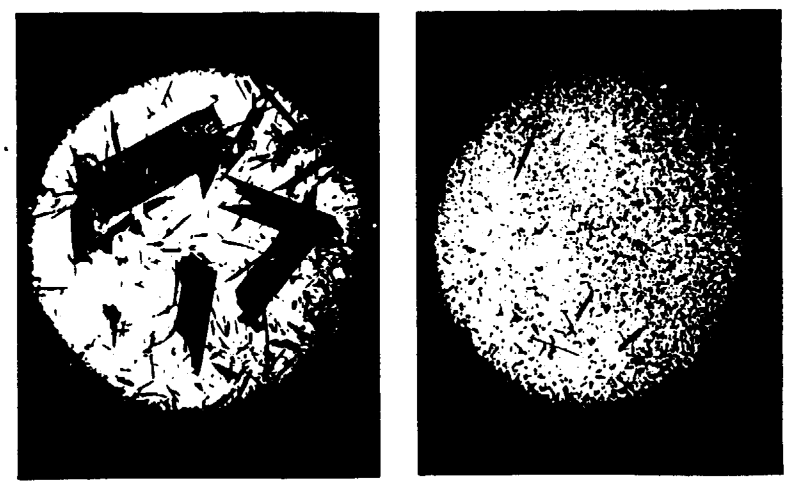
- Thermal Convection
- Sedimentation/Buoyancy
- Hydrostatic Forces
- Necessity for Container Walls

Vapor Crystal Growth In Microgravity

Microgravity conditions enhance the quality of manufactured crystal products. Experiments on Shuttle produced significantly larger and higher quality crystals.

Vapor crystal experiments in space have produced surprising and unexpected results. The flight samples had loose, web-like structures of large platelets. These experiments also produced thin crystals that grew in the gas atmosphere instead of on the ampoule wall. Some of the crystals were significantly larger than those produced on Earth; for example, one of the space-grown crystals was about 20mm by 10mm. Also, the experiment samples make it very clear that the more uniform microgravity growth conditions have a beneficial effect on surface and bulk morphology; for example, the defect density is lower (about 1% of ground-based processing) and the samples have much better planarity.

Vapor Crystal Growth in Micrograviy



(A) GROUND BASED

(B) SPACE

Summary Materials Processing in Space

Applications of the microgravity environment can be categorized by scientific discipline, by process, by type of experimental or production facility or by end product (research results or physical products).

The accompanying table was abstracted from the Microgravity and Materials Processing Facility (MMPF) contract report and represents an approach which combines some of these methods of categorization (the MMPF study is an ongoing contract effort sponsored by Marshall Space Flight Center and performed by a Teledyne Brown Engineering/Boeing team). The discipline areas shown form the basis for the definition of experimental facilities for the U.S. Laboratory Module of the Manned Space Station.

Summary Materials Processing in Space

Commercial Space

Discipline	Experiment
Bioprocessing	Collagen Processing Continuous Flow Electrophoresis Isoelectric Focusing Protein Crystal Growth
Electronic Materials	Directional Solidification Electroepitaxial Crystal Growth Float Zone Crystal Growth Solution Crystal Growth Thin Film Crystal Growth Vapor Phase Crystal Growth
Glasses and Ceramics	Acoustic Containerless Processing Glass Fibre Pulling High Temperature Glasses
Combustion	Autoignition Studies Droplet Burning Premixed Gas Combustion Solid Surface Burning
Fluids and Transport	Cloud Formation Microphysics Critical Point Phenomena Free Surface Phenomena
Metals and Alloys	Electromagnetic Containerless Processing Eutectoid Alloy Solidification Foam Metals Solidification of Immiscible Alloys Undercooling/EM Effects
Polymers and Chemistry	Membrane Produciton Monodisperse Latex Spheres Transcystallization in Thermoplastics Zeolite Catalyst Production

BOEING
Peat Marwick

Attributes / Environments

Commercial Space

3. Solar Radiation - High/Low Temperature

BOEING

Peat Marwick

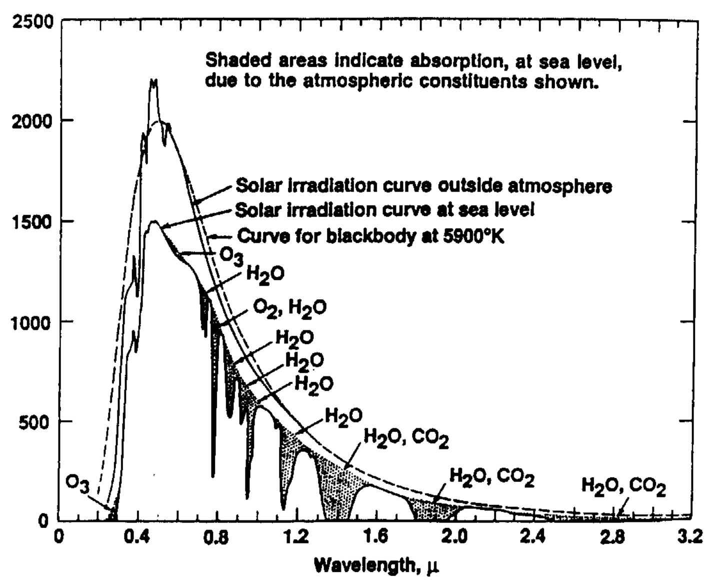
Spectral Distribution Curves Related To The Sun

The solar irradiance at satellite altitudes is higher than at sea level because there is no atmospheric absorption or scattering. Above the atmosphere the average power level from the sun is 1390 watts/m^2 The distribution over the wavelength range is shown in the chart. The curve for a black body radiator at 5900° K is also shown. There is a seasonal variation of approximately $\mp$ 3% due to changes in solar distance from summer to winter.

The solar irradiance at sea level is reduced by about 25%. The absorption bands, shown in the chart are primarily due to water vapor, carbon dioxide and ozone.

Solar irradiance is a major driver in spacecraft design. Configuration of solar cell arrays for electric energy production, thermal insulation blankets and cooling radiators for internal heat control, and exterior instrumentation of all kinds must be designed to accommodate solar energy.

Spectral Distribution Curves Related to the Sun



Commercial Space

BOEING

Peat Marwick

C-2

Solar Furnace

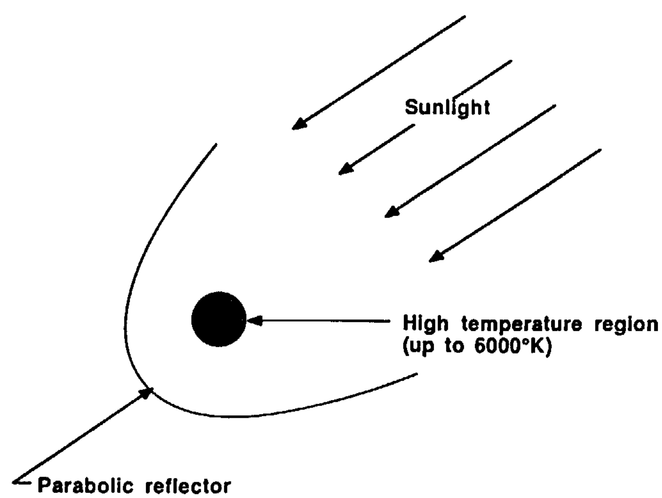
Material processing furnaces require large energy sources that are hard to maintain in space. Concentration of solar energy provides a convenient and potentially continuous source of furnace power. High concentration ratios are essential so large optics are required.

The theoretical maximum temperature obtainable is approximately 5900° K (equal to the black body temperature of the sun). In practice however, thermal losses will determine the operating temperature. Soviet rocket experiments with 300 fold concentration have provided temperatures of several hundred degrees centigrade. Most low earth orbits, except for the special case of sunsynchronous orbits, well require continuous reorientation of the optical concentrator system to compensate for satellite motion.

Solar Furnace

Commercial Space

High temperatures readily available using solar furnaces



BOEING
Peat Marwick

Low Temperature Deep Space

The universe has background temperature of 3° Kelvin or -454° F. If one looks away from the Sun and the Earth, this cold background predominates and can be used as a low temperature reservoir or heat sink. The background acts like a 3° K black body radiator witha predominant wavelength at 1 millimeter although the radiation has components at other wavelengths. It is temporally constant and extremely isotropic (uniform in all directions) and can be used to calibrate radio frequency (RF)receivers.

High/Low Temperature Heat Sink/Source

A combination of the solar radiation as a heat source and the low temperature background as a heat sink can be used to solve the increasingly complex problem of total thermal control of spacecraft.

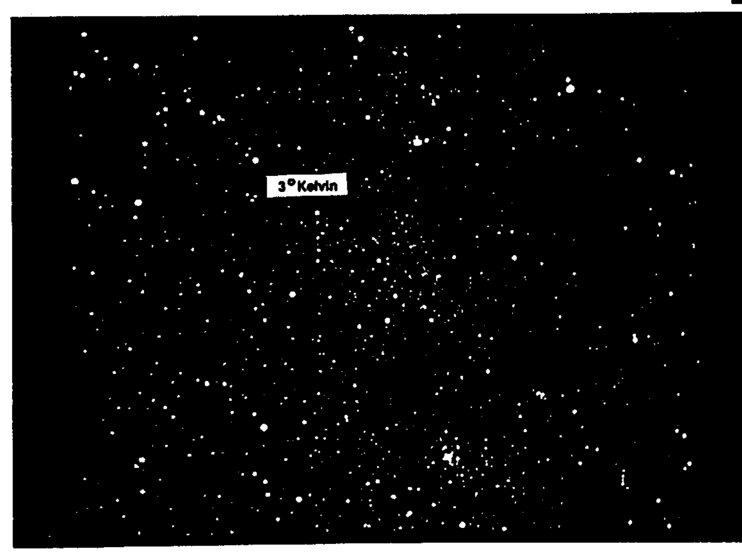
Sunlight can be used with solar panels to produce electrical power for spacecraft operations. High temperature furnaces can be operated by using a solar concentrator.

The low temperature background can be used as a sink for waste heat from manufacturing applications and can also be used to operate heat engines at high efficiency.

The complete thermal control of spacecraft operations can be achieved using a balance of heat input with solar thermal collectors and heat output using thermal radiators.

Sagittarius Star Cloud

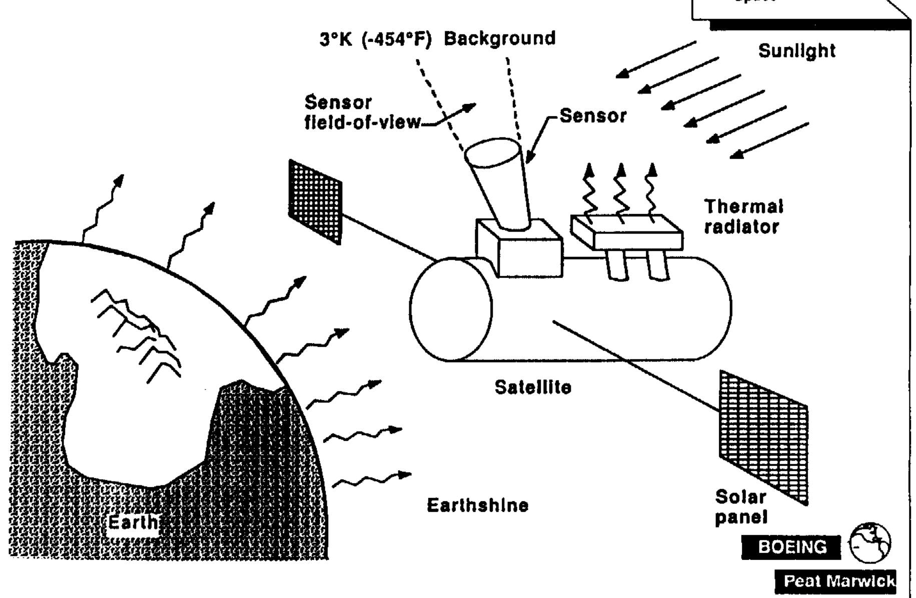
Commercial Space



BOEING

Peat Marwick

High / Low Temperature Heat Source /Sink



Attributes / Environments

Commercial Space

4. High Vacuum

BOEING

Peat Marwick

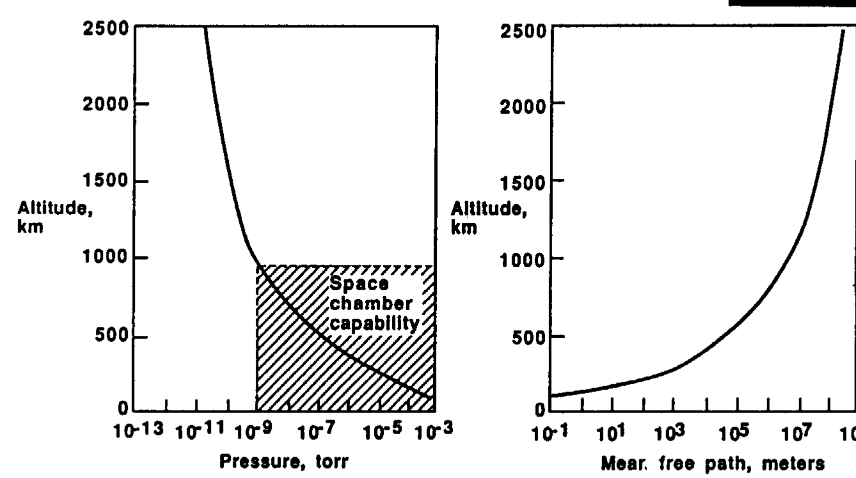
Atmospheric Pressure and Neutral Molecular Mean Free Paths

On the left the chart shows the decrease of atmospheric pressure with altitude for typical conditions. Significant variations can occur, caused by changes in solar activity. Large space chambers can be used to simulate atmospheric pressure (and other) conditions for values above about 10^{-9} torr, corresponding to altitudes below approximately 1000km. On the right the chart shows that the particle mean free path (average distance traveled between collisions) increases with altitude. At low earth orbit altitudes MFP is much greater than spacecraft dimensions.

The mean free paths in the chart have been estimated for neutral particles in a typical atmosphere having an average molecular constituency. The neutral particle mean free path, which is determined by elastic (non-coulomb) collisions is of the order of 10 to 100km at low earth orbit altitudes, indicating that self scattering is negligible.

Atmospheric Pressure and Neutral Molecular Mean Free Path

Commercial Space



BOEING

Peat Marwick

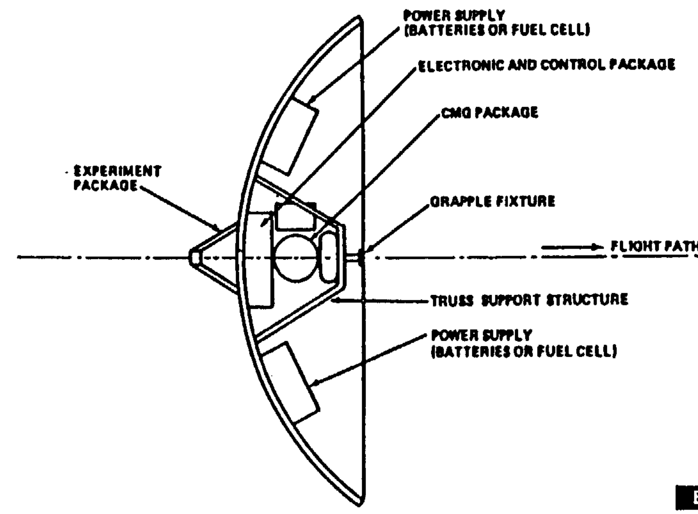
Space Ultra-Vacuum Facility Concept

At 300km the atmospheric pressure is about 10^{-7}-10^{-8} torr. Some processes, including the growth of pure crystalline films with molecular beams require even lower pressures. The speed of a spacecraft in orbit is greater than the speed of the residual particles in the atmosphere, which means that there is a very low pressure region in the wake of the space craft.

The space ultra-vacuum research facility (SURF) proposed by NASA/MSFC utilizes a large concave wake shield to produce an exceptionally low pressure in low earth orbit. Support instrumentation is located on the concave side facing the orbital direction. Experiments are conducted at the center of the convex side in the wake region of the shield. Pressures around 10^{-14} torr behind the wake shield would support molecular beam epitaxy (MBE) and chemical beam epitaxy (CBE).

Space Ultra-Vacuum Facility Concept

Commercial Space



BOEING
Peat Marwick

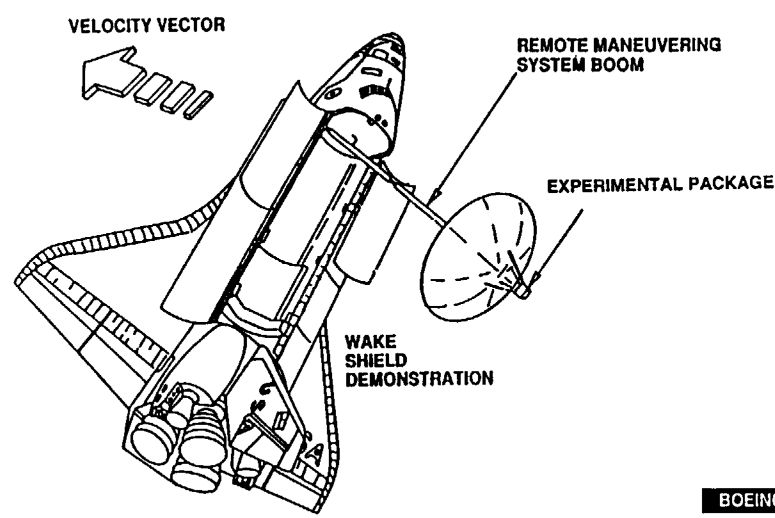
Wake Shield Deployment by Orbiter

The shuttle provides an opportunity for easy deployment of the wake shield ultra high vacuum system using a remote maneuvering boom. Many options for the deployment of the shield would be available on the space station.

The effectiveness of the wake shield can be enhanced by orienting the shuttle so that the shield is already in the wake of the shuttle. Care must be taken so that gas leakage from the shuttle itself does not negate the effects of the shield.

Wake Shield Deployment by Orbiter

Commercial Space



BOEING
Peat Marwick

Attributes / Environments

Commercial Space

5. Residual Atmosphere

BOEING

Peat Marwick

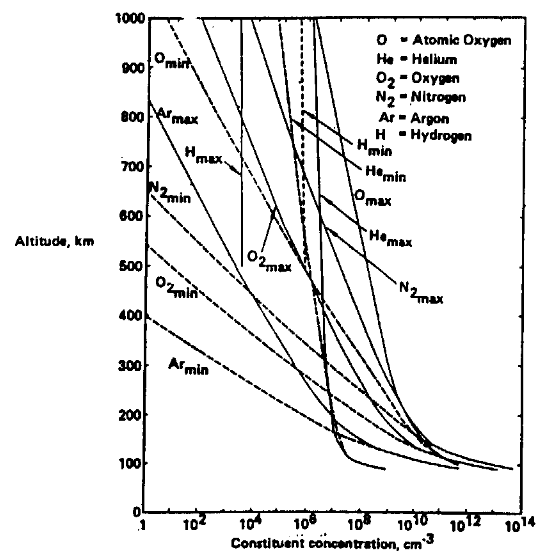
Atmospheric Constituent Number Density

Although pressures at satellite altitudes are very low, the Earths atmosphere does extend tenuously to these altitudes. The atmosphere is mainly atomic oxygen produced by solar-photo dissociation of molecular oxygen.

The chart shows the variation of atmospheric constituent number density with altitude calculated using the MSFA/JTO standard neutral density model. The maximum and minimum values are for maximum solar conditions at 1400 hrs and minimum solar conditions at 0400 hrs respectively. Note the anomalous behavior of Hydrogen which shows higher concentrations for the solar minimum than for the solar maximum.

The results are based on a static diffusion model and are in agreement with experimental data from satellite drag observations.

Atmospheric Constituent Number Density (Maximum and Minimum Solar Conditions)



Commercial Space

BOEING

Peat Marwick

ORIGINAL PAGE IS OF POOR QUALITY

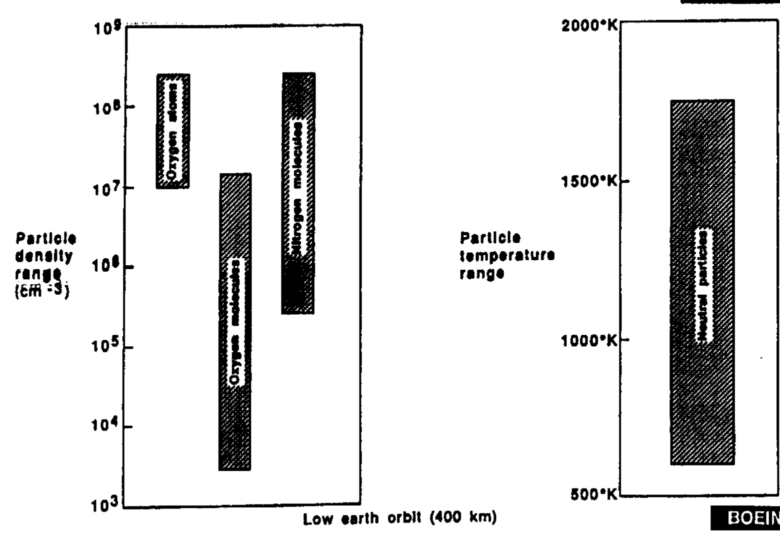
Neutral Atmosphere Density and Temperature

The bar chart shows the range of densities for the three major neutral particle constituents of the atmosphere at an altitude of 400 km. The bulk temperature range for the neutral atmosphere is also shown.

The largest part of the variation in the density and temperature is associated with the sun spot cycle and is probably due to changes in the ultraviolet light output of the sun. The remainder of the variation is due mainly to the diurnal cycle.

Neutral Atmosphere Density and Temperature

Commercial Space



BOEING
Peat Marwick

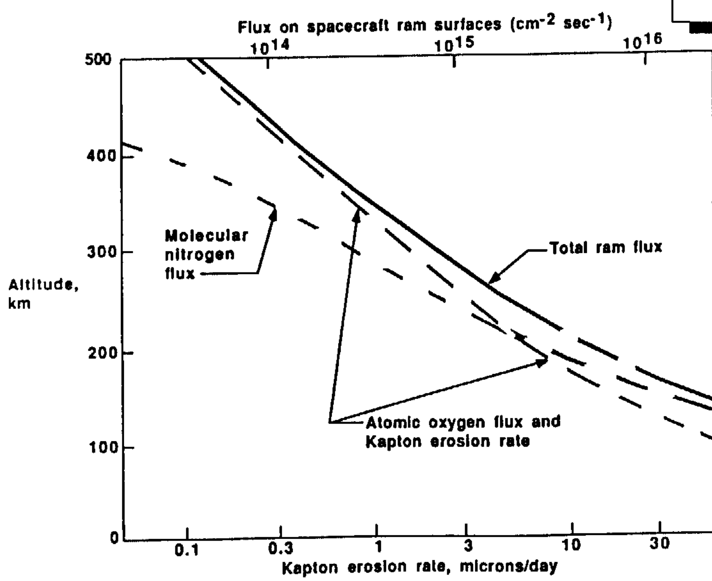
Atmospheric Particle Flux and Surface Interactions

The orbital motion of low altitude spacecraft creates a ram wind of neutral atmospheric gases. Atomic oxygen, the primary constituent, is chemically active with many materials conventionally used on spacecraft exteriors. Degradation of plastic thermal blankets, binders in protective paints, optical coatings on lenses, and silver interconnects on solar panels has adversely affected performance. The chart shows the flux of oxygen and nitrogen and the erosion rate of Kapton as a function of altitude. Fortunately, aluminum forms an oxide that halts further interraction.

The ram flux provides a unique environment for surface treatment of materials. Atomic oxygen strikes ram surfaces with 4.8 ev of kinetic energy whereas molecular nitrogen because of its greater mass has 8.4 ev. These energies are comparable to molecular binding energies in many materials. Such conditions provide the opportunity for large-scale creation of new surface oxides under controlled conditions currently unavailable in the laboratory.

Atmospheric Particle Flux and Temperature Surface Interations

Commercial Space



BOEING

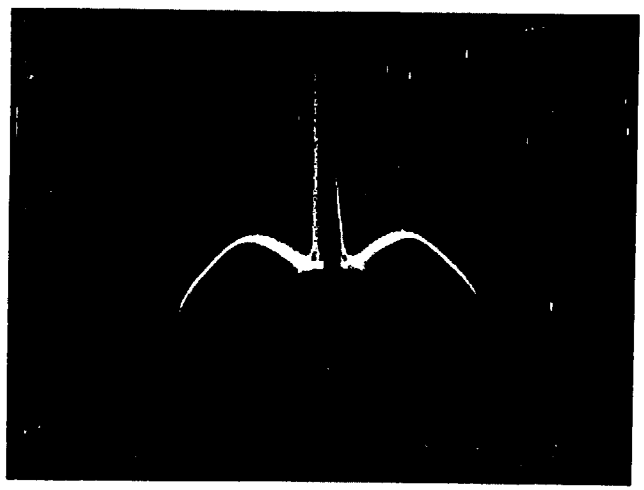
Peat Marwick

Shuttle Glow

A second phenomenon associated with the residual atmosphere was observed early in Shuttle missions. A visible glow, caused by optical excitation of the residual atmosphere was observed on the leading edges of the shuttle. This photo was taken of the aft payload bay as the Shuttle traveled in the direction of its vertical stabilizer. The thin region of light (about 20 cm thick) is emitting visible and very near infrared radiation (up to 0.9 microns). The photograph is restricted to these wave lengths by the optical transmission of the lens.

Shuttle Glow

Commercial Space



BOEING

Peat Marwick

Attributes/Environments

Commercial Space

6. Ionosphere

BOEING
Peat Marwick

Residual Atmosphere and Ionosphere (At Low Earth Orbit Altitudes)

The earth's atmosphere extends tenuously to Low Earth Orbit altitudes as described in the previous Section. The neutral particles are mainly atomic oxygen produced by Solar photo dissociation of molecular oxygen. Approximatley one percent of the oxygen atoms are photo-ionized producing a plasma known as the ionosphere. The plasma consists mainly of positively charged oxygen ions and electrons and negative oxygen ions. Although it represents only about one percent of the gas, the plasma determines many of the properties of the gas such as the electrical conductivity and the propagation characteristics of electro-magnetic waves.

The neutral and charged particle densities will be much higher on the forward facing (or RAM) surfaces and much lower on backward facing (or WAKE) surfaces.

The characteristics of the ionospheric plasma are described in the following charts.

Residual Atmosphere and Ionosphere (at Low Earth Orbit Altitudes)

Commercial Space

- Earth's atmosphere extends to low Earth orbit
- About 1 percent of atmosphere is ionized, forming a plasma

Residual Neutral Atmosphere	Ionosphere
99 percent	1 percent
Oxygen atoms, oxygen and nitrogen molecules	Electrons and oxygen ions
Traces of hydrogen and argon	Traces of nitrogen ions
Variations caused by solar activity	Variations caused by solar activity
Determines atmospheric drag and chemical characteristics	Determines electrical properties and electromagnetic wave propagation characteristics

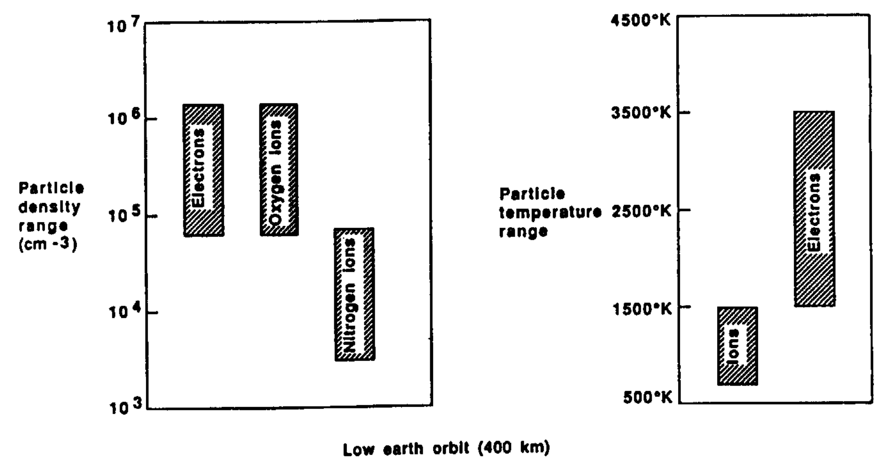
BOEING
Peat Marwick

Charged Particle Densities and Temperatures

The bar chart shows the range of densities and temperatures for the major ionized species in the ionospheric plasma. As is the case with the neutral particles the ranges are due in great part to variations in solar sunspot activity and diurnal variations. It should be noted that the charged particles, unlike the neutral particles, are not in thermal equilibrium, the temperature of the electrons being considerably higher than that of the ions. This, coupled with the smaller mass of the electrons means that the velocities of the electrons are much higher than the velocity of the spacecraft, which in turn is much higher the ion and neutral particle velocities.

"An orbiting spacecraft is supersonic with respect to ions and stationary with respect to electrons".

Charged Particle Densities and Temperatures



Commercial Space

BOEING
Peat Marwick

Natural Plasma Environment

The chart summarizes in tabular form the plasma and charged particle data which has been described in the previous few pages for typical ambient conditions in a 400 km low inclination orbit. The table shows the ion and electron number densities and temperatures and the associated thermal velocities. The thermal velocities are shown both in units of km/sec and the satellite orbital velocity, Vs. Numbers are also shown for the ion and electron fluxes per unit area of the satellite. The ion and electron gyro radii in the earth's magnetic field are also shown. The electron gyro radius is only 0.033m. Indicating that the electrons are almost completely constrained to move parallel to the magnetic field lines and that the properties of the ionospheric plasma will be very anisotropic.

Natural Plasma Environment

Commercial Space

Typical ambient conditions
(400 km - low orbit inclination)

Oxygen ion O^+ (90%)	Electron e^- (100%)
$N_i = 2 \times 10^{11}\ m^{-3}$	$N_e = 2 \times 10^{11}$
(Day: $2 \times 10^{11} - 10^{12} m^{-3}$, night: $7 \times 10^{10} - 10_{11}\ m^{-3}$)	
$T_i = 1000°K$ (0.09 eV)	$T_e = 2500°K$ (0.33 eV)
$V_i = 1.2\ km\ S^{-1}$ ($0.15 V_S$)	$V_e = 300\ km\ S^{-1}$ ($39\ V_S$)
(V_S = spacecraft orbital velocity = $7.7\ kmS^{-1}$)	
$r_i\ B$(gyro radius) = 4.2 m	$r_e B = 0.033$ m (B = 0.4G)
$N_i V_S$ (flux) = $1.5 \times 10^{15}\ m^{-2}\ S^{-1}$	$N_e V_e = 3.5 \times 10^{16}\ m^{-2}\ S^{-1}$

BOEING
Peat Marwick

Ionospheric Wave Propagation

The ionospheric plasma has a dramatic effect on electromagnetic wave propagation. The electron density (Ne) in a plasma determines a natural frequency called the "plasma frequency". Numerically the value of the plasma frequency is given by f_p=8980 $Ne^{1/2}$ Hz. At frequencies above the plasma frequency electromagnetic waves are transmitted without significant loss, whereas at frequencies below the plasma frequency the wave is rapidly attenuated. If a wave is propagating through a plasma in which the density is increasing with distance, the wave continues to propagate until it reaches the point where its frequency is equal to the plasma frequency and it is then reflected.

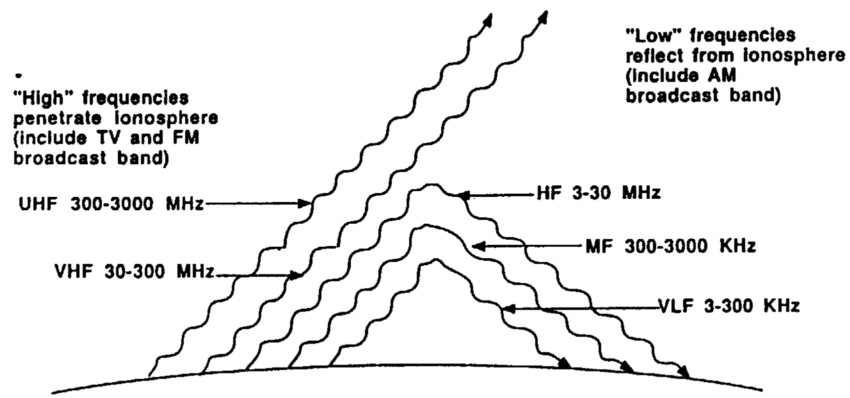
The plasma frequency in the ionosphere increases with height to a maximum value and then decreases. If the frequency of the electromagnetic waves is higher than the maximum the waves penetrate the ionosphere. If not, they reflect at the appropriate height as shown in the chart, and communication "over the horizon" is possible. For communication between the surface and a satellite the signal frequency must obviously exceed the maximum plasma frequency in the ionosphere.

A plasma, particularly one with a magnetic field, such as the ionosphere, is capable of supporting a wide variety of propagation modes including accoustic and hybrid modes. The opportunity to perform propagation experiments in the ionospheric plasma is one of the attractions of the low earth orbit environment.

Ionospheric Wave Propagation

Commercial Space

- Ionospheric plasma modifies electromagnetic wave propagation
- Waves higher than "plasma frequency" transmit
- Waves lower than "plasma frequency" reflect



BOEING

Peat Marwick

Attributes/Environments

Commercial Space

7. Geomagnetic Field

BOEING

Peat Marwick

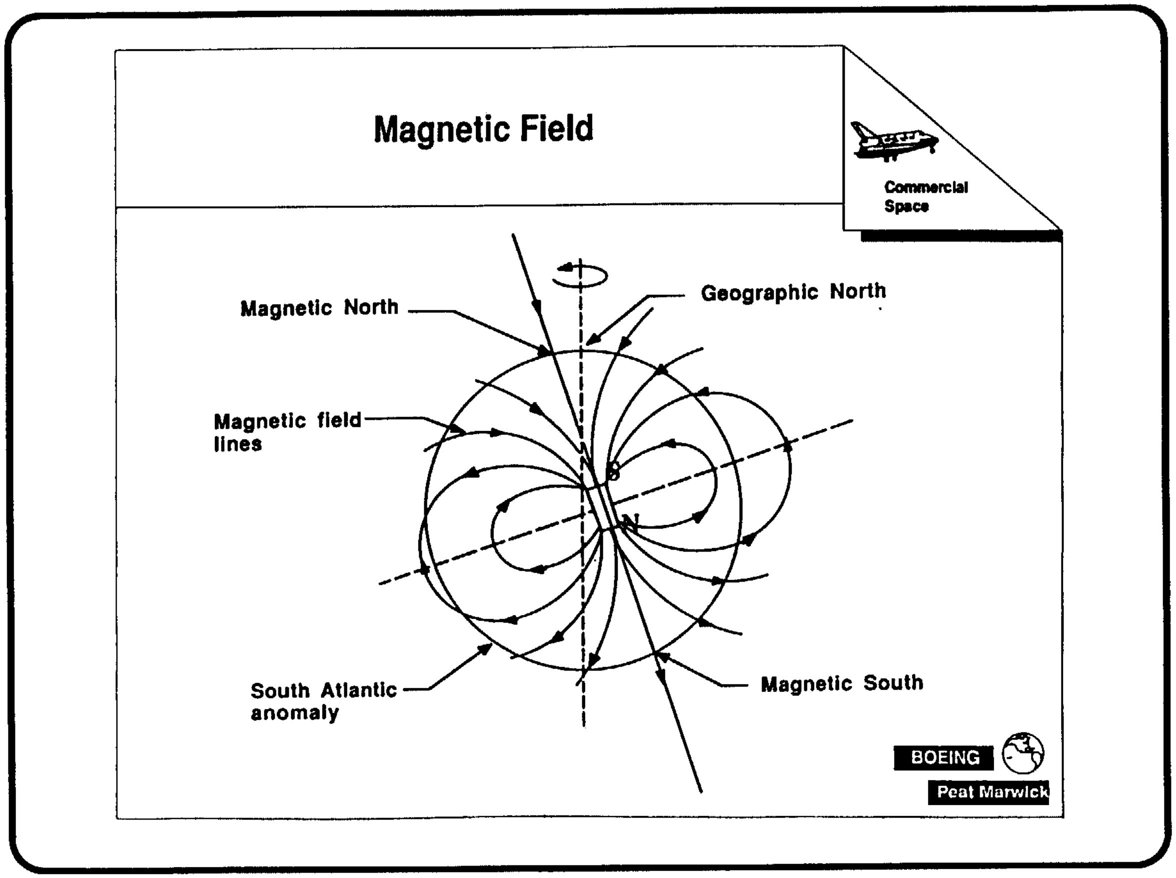
Magnetic Field

The gross features of the geomagnetic field are those of a magnetic dipole whose axis is tilted about 10° from the earth's geographic or spin axis.
The center of the dipole is also displaced about 500 km from the geometric center of the earth. The displacement produces a region of low magnetic field strength at the earth's surface, known as the South Atlantic Anomaly.

The main magnetic field probably originates by dynamo action in the fluid motion of the molten magnetic core of the earth. Transient variations are produced chiefly by interaction between solar plasma and the geomagnetic field.

The geomagnetic field acts as a partial shield against charged particles by bending them away from the earth's surface at low latitudes and by reflecting them at high latitudes.

At high altitudes the magnetic field is distorted by the solar wind and merges with the interplanetary magnetic field.


Magnetic Field
Commercial Space
Magnetic North
Geographic North
Magnetic field lines
S
N
South Atlantic anomaly
Magnetic South
BOEING
Peat Marwick

Magnetic Field Contours

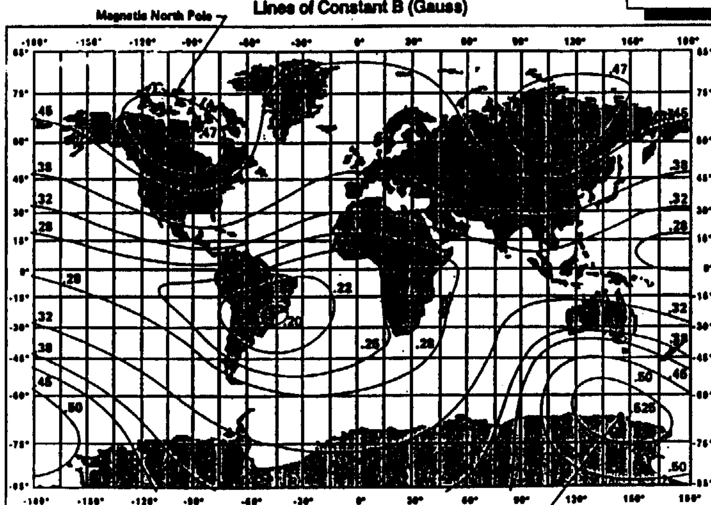
The chart shows contours of constant total magnetic field strength at an altitude of 500 km. At such altitudes local surface scale variations due to iron ore deposit are not observed, the field strength decreases with altitude approximately proportionally to 1/R where R is the distance from the center of the earth. At polar latitudes the magnetic field is nearly vertical, having a value of about 0.5 gauss (0.5 x 10 Tesla). The field changes to mainly horizontal at equatorial latitudes where it has a magnitude of about 0.3 gauss except in the South Atlantic Anomaly, which can be clearly seen in the chart.

The locations of the North and South Magnetic Poles change with time. They are currently located at approximately 75° N, 100° W and 65° S, 140° E respectively.

Magnetic Field Contours

Commercial Space

Lines of Constant B (Gauss)



Altitude = 500 km

BOEING

Peat Marwick

ORIGINAL PAGE IS OF POOR QUALITY

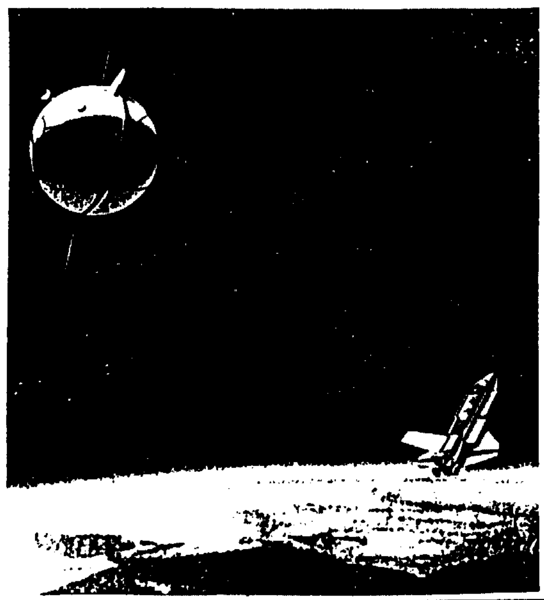
Tether - Subsatellite Power

An electromotive force (emf) is produced in a conductor as it traverses a magnetic field. The magnitude depends on the velocity and the magnetic field strength and direction. At low earth orbital velocities it is about 0.5 volts per meter of conductor length.

Conducting tethers between satellites can be used to generate power if one satellite collects electrons from the ionospheric plasma while the other emits them so that electric current can flow. Primary factors that limit power generation are collector area, plasma density, tether wire and load resistance, and emitter capacity. Power levels of a few kilowatts per kilometer are conceivable. An experimental tethered subsatellite for Shuttle deployment is being fabricated by Aeritalia to test the concept. The subsatellite must have elaborate guidance and control to perform the complex orbital maneuvers.

Tethered, Electrodynamics Mission

Commercial Space



BOEING

Peat Marwick

Attributes/Environments

Commercial Space

8. Ionizing Radiation

BOEING

Peat Marwick

Ionizing Radiation

The near earth space environment is bombarded by high energy particles: protons, electrons, alpha particles, and other ions. Some of the particles have sufficiently high energy that they can penetrate material and in so doing they lose energy by ionizing the material. They are collectively called "Ionizing Radiation".

There are three main components of this natural radiation surrounding the earth: the trapped Van Allen belts (protons and electrons trapped by Earth's magnetic field), galactic comic rays (protons and high energy ions orginating outside the solar system) and solar cosmic rays (protons and alpha particles emitted by intense solar flares, 30-50 such events per 11-year cycle). The different components of the radiation are discussed in the next few charts.

The high energy, highly charged ions of the GCR can be simulated at only a few facilities worldwide, but with significant limitations (low atomic number, energy <100 Mev/nucleon; the BEVALAC at Berkeley California has fewest limitations).

Ionizing Radiation

Commercial Space

High energy particles (radiation) penetrate the near Earth space environment

- Main sources of high-energy radiation
  - Trapped radiation belts
  - Galactic Cosmic Rays (GCR)
  - Solar Cosmic Rays (SCR)
- Types of radiation
  - Protons (trapped belt, GCR, SCR)
  - High energy ions (GCR)
  - Electrons (trapped belt)
- Ability to simulate space radiation
  - High energy protons — large cyclotrons
  - High energy ions — Berkeley BEVALAC
  - Electrons — linear accelerators

BOEING

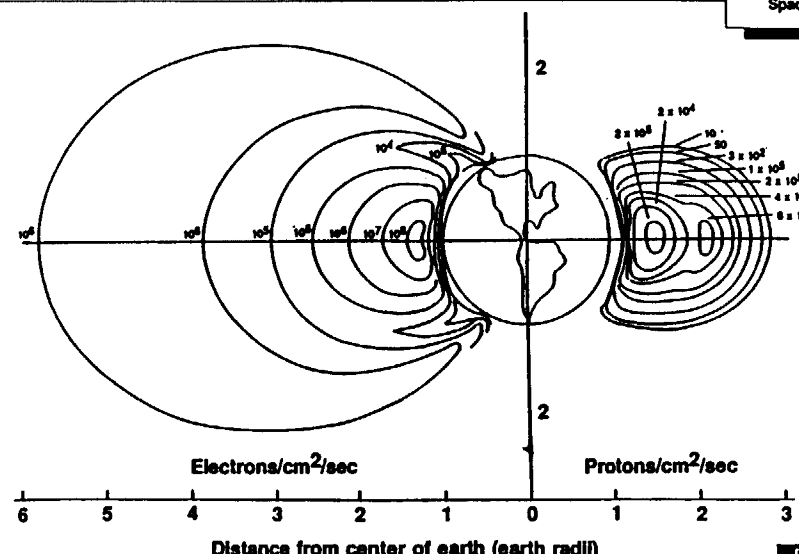
Peat Marwick

Trapped (Van Allen) Radiation Belts

High-energy protons and electrons are trapped by the geomagnetic field in Van Allen radiation belts. In the radiation belts the charged particles follow spiral orbits along magnetic field lines and are reflected by increasing field strength near earth. The chart shows crescent-shaped flux contours which encircle globe out to several earth radii.

The discovery of the trapped radiation belts in 1958 was a key milestone in space research. The electrons collide with atoms in the outer skin of the spacecraft creating penetrating x-rays and gamma rays that cause tissue damage. The energetic protons can penetrate several grams of material (1-2cm of aluminum is required to stop them) causing ionization of atoms as they terminate in nuclear collisions. Most manned spacecraft missions are restricted to altitudes below 500km to avoid prolonged exposure to this damaging radiation. The lower edge of the belts is controlled by the geomagnetic field and scattering by the upper atmosphere.

Trapped (Van Allen) Radiation Belts



Trapped Belt Electron Flux

Electrons trapped by the earth's magnetic field are part of both the inner belt (500-12,000 km) and the outer belt (18,000-36,000 km). The electron flux peaks at altitudes ranging from approximately 2000-5000 km in the inner belt and at approximately 20,000 km in the outer belt, depending on the electron energy. The electron flux is shown at an altitude of 500 km in the chart.

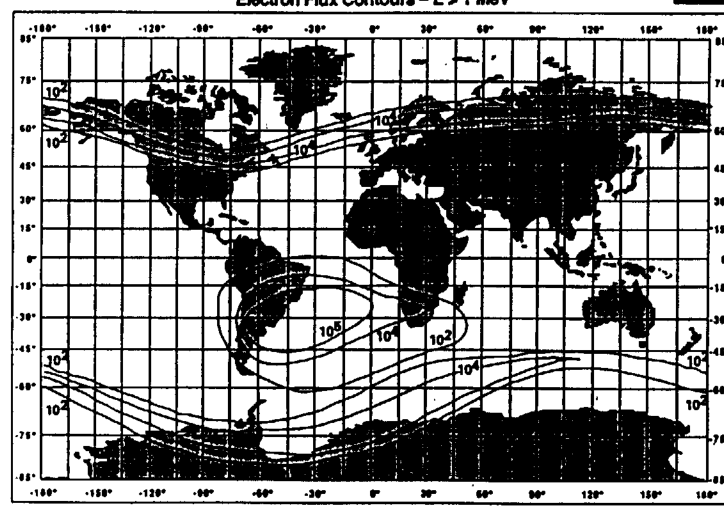
Because of a sharp decrease in the earth's magnetic field in the area of the South Atlantic, the inner belt electron flux has a high value area known as the South Atlantic Anomaly.

At high latitudes the geomagnetic field lines "bunch in" toward the magnetic poles, allowing energetic electrons of the outer belt to follow the field lines down to low altitudes.

Trapped Belt Electron Flux

Commercial Space

Electron Flux Contours – E > 1 MeV



Altitude = 500 km

BOEING

Peat Marwick

ORIGINAL PAGE IS OF POOR QUALITY

Trapped Belt Proton Flux

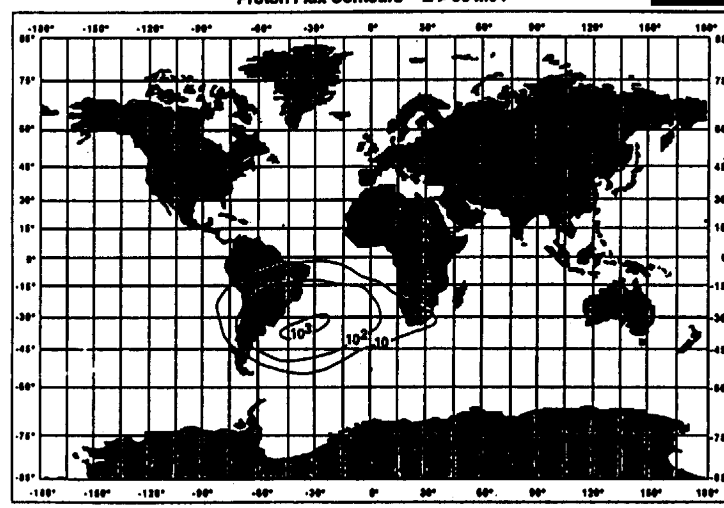
Protons trapped by the geomagnetic field are part of the inner trapped belt which extends from about 500-12,000 km and peaks at approximately 2000-5000 km, depending on the proton energy.

As for the electrons the proton flux peaks over the South Atlantic Anomaly. At Shuttle and Space Station altitudes, i.e. an altitude of 500 km, the only appreciable proton flux is encountered in the South Atlantic Anomaly as shown in the chart.

Trapped Belt Proton Flux

Commercial Space

Proton Flux Contours – E > 50 MeV



Altitude = 500 km

BOEING

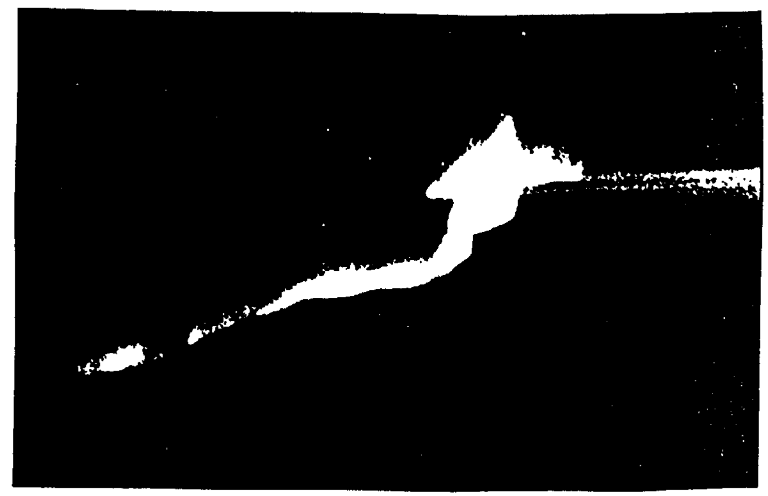
Peat Marwick

Aurora

The Aurora Borealis and Australis are visible manifestations of the intense activity in the geomagnetic field surrounding Earth. Observed and studied since ancient times, its true explanation awaited the discovery of the trapped radiation belts. Disturbances in the geomagnetic field scatter trapped electrons and protons into the upper atmosphere at high latitudes where they excite the oxygen and nitrogen atoms and molecules. The variety of auroral color is due to mixing of line emissions from the discrete excited states of the atmospheric gases.

The spatial variability of aurora is demonstrated in this satellite photo of the auroral band extending thousands of miles across the northern hemisphere. Interraction of solar flare plasma with the geomagnetic cavity causes periods of enhanced activity when aurora becomes visible in the continental U.S.

Satellite Observations of Aurora



Commercial Space

BOEING

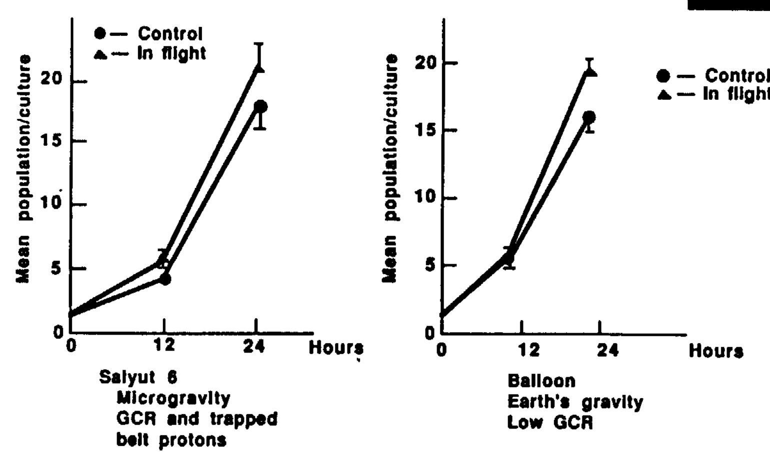
Peat Marwick

Enhanced Growth of Microorganisms in Space

The effect of radiation on biological systems has generally been harmful. This includes the induction of developmental anomalies in animals, cancer in humans, mutations in plants and retardation of all development and colony formation in microorganisms. However, experiments with paramecium tetraurelia, a simple, unicellular organism, have shown enhanced colony growth due to the combined effect of space radiation and microgravity. This leads to the prospect of enhanced growth in more useful microorganisms, e.g., euglena, bacteria spores, genetically-engineered biomolecules. Additional radiobology experiments in space may therefore be of interest to pharmaceutical firms.

Enhanced Growth of Microorganisms in Space Radiation

Commercial Space



Growth rate of Paramecia cultivated and fixed in a balloon flight or aboard the orbital station Salyut 6

BOEING

Peat Marwick

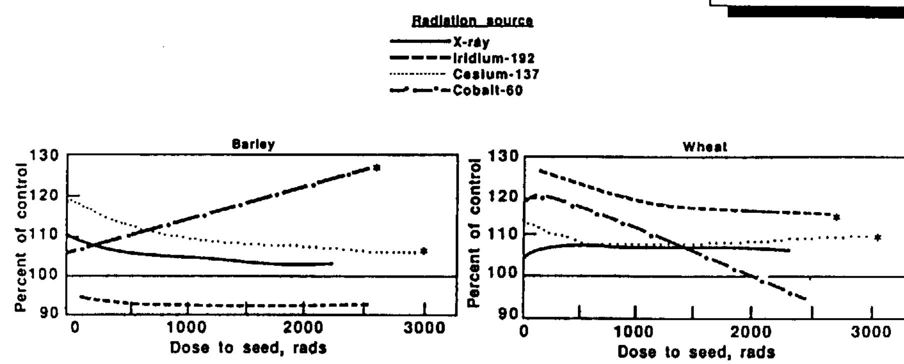
Radiation Hormesis

At low doses, radiation has been shown to have a hormetic, i.e. stimulating, effect on the growth of both plant and animal organisms. For plants in particular, the hormesis response is a common phenomenon that is not restricted to either plant species or radiation type. The chart shows the change in growth to barley and wheat as a function of radiation dose, when exposed to four different radiation sources.

For space-food growing experiments relying on the growth of many generations of plant cycles, this hormetic effect may be important for increasing the food yield. The hormetic radiation effect could be delivered by using either the natural space radiation or on-board radiation sources.

Radiation Hormesis

Commercial
Space



Estimates of relative dry weight at 11 d of barley and wheat plants grown in the growth chamber from seed irradiated with four different sources

BOEING

Peat Marwick

Cosmic Ray Induced Single Event Upset

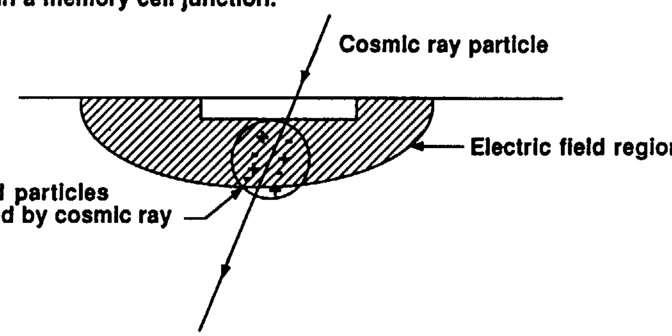
A Single Event Upset (SEU) is an anomolous change in a semiconductor logic device. SEUs in modern electronics in space are caused by cosmic ray particles or trapped protons. As the particles pass through material they lose energy by ionizing the material and producing additional pairs of charged particles. If the charged particles are near the junction of a semiconductor device in a memory cell they can produce a current pulse large enough to cause a change in state of the memory cell. No permanent damage is done, but the data store in the cell is now in error. Such errors induced in existing spacecraft are causing significant reductions in system lifetime and reliability.

Development of large scale integrated circuits, coupled with the decreasing size of individual circuit elements, has made space borne electronics increasingly susceptible to SEU because the current required to change the state of the memory cell has become smaller and smaller. Techniques are evolving to reduce the system error rates to a tolerable level.

Cosmic Ray Induced Single Event Upset

Commercial Space

- Single Event Upset (SEU) is caused by a cosmic ray induced current pulse in a memory cell junction.



- Charged particles move in the electric field of the junction.
- The current produced causes the memory cell to change state.
- Erroneous information is stored in memory

BOEING
Peat Marwick

Attributes/Environments

Commercial Space

9. Meteoroids/Debris

BOEING

Peat Marwick

Meteoroid Environment - Terrestrial-Space Influx of Meteoroids

Most meteoroids originate from comets or asteroids outside earth orbit and hence have high velocities. Meteoroids from comets are icy. Meteoroids from asteroids are stony and may contain silicon, iron, magnesium, and other minerals. Since the major source of meteoroids is comets, the average density is around $0.5 g/cm^{-3}$.

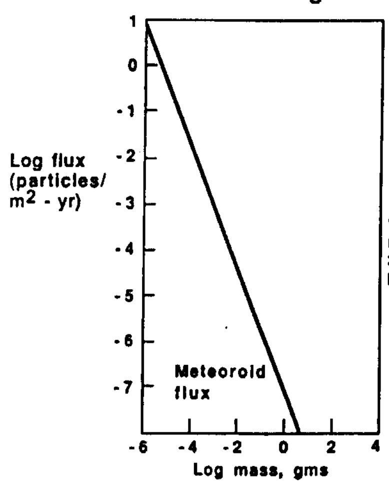
Meteoroid Environment does not change significantly from year to year, although the hourly influx may vary as the Earth moves through the meteoroid streams left in the orbital paths of comets or fragmented asteroids. The total mass influx to the Earth is estimated to be 10^{10} grams per year.

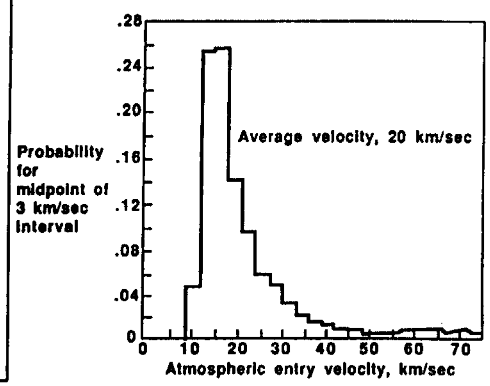
Meteoroid influx is measured with: impact detectors on satellites, visual observation of meteor trails in the atmosphere, zodical lights, lunar crater accounts, and by retrieving meteoroid material from the sea floor and from the polar icecaps. The meteoroid flux line results from many sources of data and shows that meteoroid size is inversely related to frequency. The flux for meteoroids less than 10^{-12} grams is uncertain.

Meteoroid Environment -- Terrestrial-Space Influx of Meteoroids

Commercial Space

Average Mass Density = 0.5 g/cm^3





Source: NASA SP 8013 Meteoroid Environment Model — 1969

BOEING

Peat Marwick

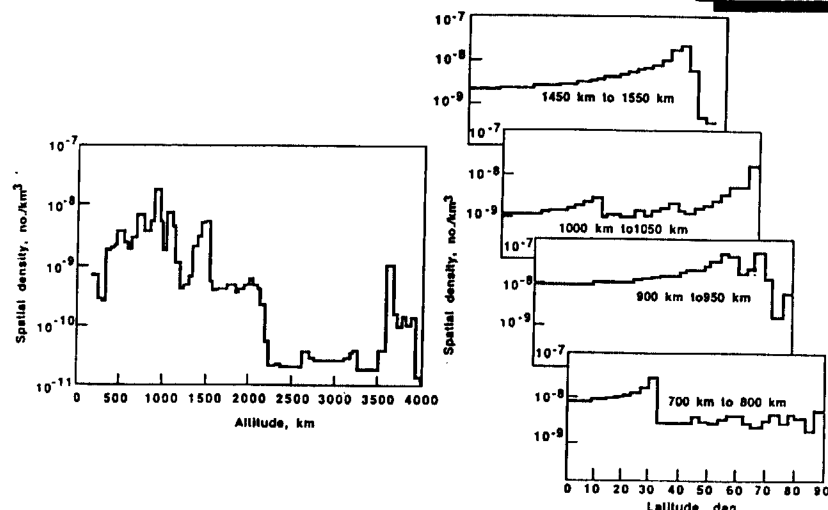
ORIGINAL PAGE IS OF POOR QUALITY

Orbital Debris Environment
Altitude and Latitude Variation

Debris is created during orbital activity. The sources of orbital debris include fragments from satellite destruction (collisions and explosions) and objects released during routine orbital operations. The debris environment shown in the charts is measured using ground based radar. Currently approximately 5,000 objects are tracked and including those below the radar threshold it is estimated that there are from 10,000 to 15,000 particles in orbit. The chart shows the variation of debris density (particles per unit volume) as a function of altitude and latitude. The variations are due to orbital decay and the preferential use of some altitudes and orbital inclinations.

Orbital Debris Environment -- Altitude and Latitude Variation

Commercial Space



BOEING

Peat Marwick

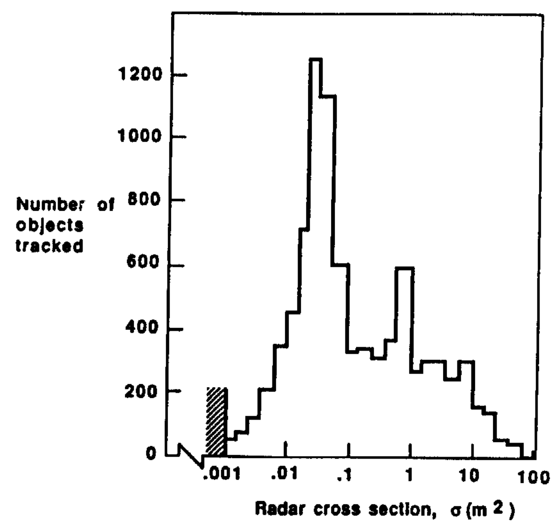
ORIGINAL PAGE IS OF POOR QUALITY

Radar Tracked Objects In Low Earth Orbit

Debris size distribution is obtained from radar cross section measurements. Radar sensitivity for small objects is low, therefore the number of small objects in orbit is greater than detected by radar. Flux for these small objects is estimated from extrapolations of known satellite explosions and is assumed similar to the meteoroid flux.

Radar Tracked Objects in Low Earth Orbit

Commercial Space



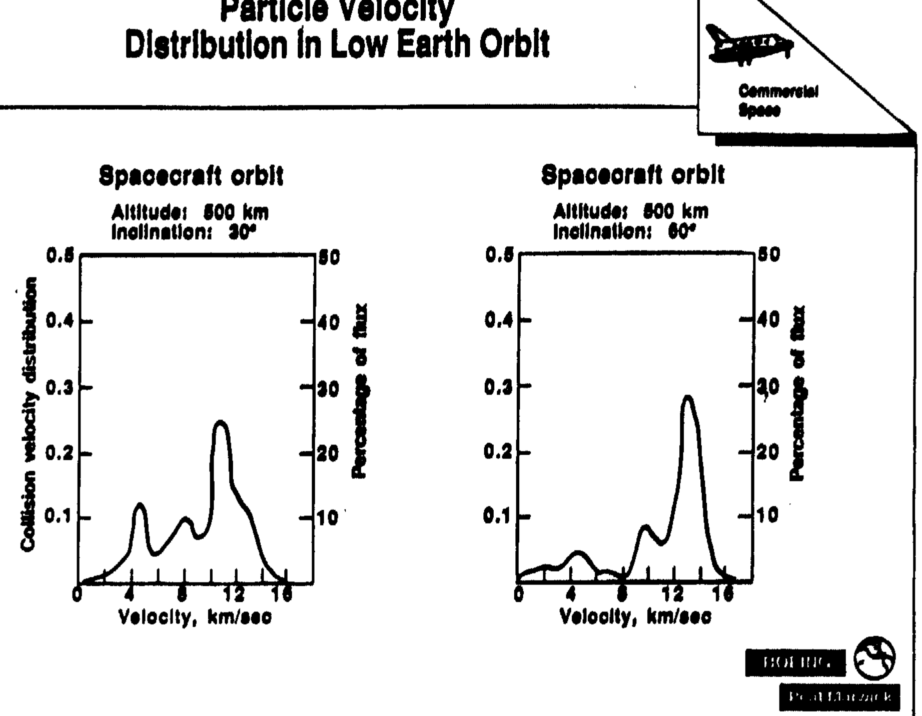
BOEING

Peat Marwick

Particle Velocity Distribution in Low Earth Orbit

The velocity of collisions between spacecraft and orbital debris depends on the spacecraft orbit. Most debris impacts occur between 8 km/s and 16 km/s. The velocity distributions are shown in the chart and are derived from the orbital mechanics of the spacecraft and known debris orbits. The majority of expected debris impacts will occure above 8 km/s, which is the limit of current testing capability.

Particle Velocity Distribution in Low Earth Orbit



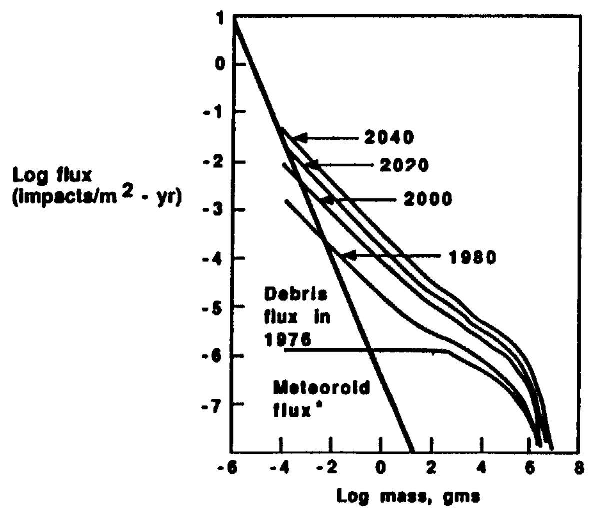
Orbital Debris and Meteoroid Flux and Growth Predictions

The chart shows the debris and meteoroid flux represented as the expected number of impacts per unit area per unit time on a spacecraft in orbit at 800 km altitude. As the spacecraft size and mission length increases, more impacts of larger particles will be expected. The debris flux is more important than the meteoroid flux because debris particles large enough to penetrate spacecraft are more numerous. The debris flux is not expected to change significantly with orbit inclination. The meteoroid flux has been corrected for earth shielding and gravity focusing.

In the middle 1970's, during the use of Sky Lab, the orbital debris flux was much less than present. Continued growth is expected in debris flux. The chart shows the predicted growth in debris flux for an altitude of 800 km. Similar growth rates are expected at other altitudes. The debris flux increases with time because debris continues to be released during orbital activity and because existing debris fragments collide with each other producing more particles.

Orbital Debris and Meteoroid Flux and Growth Predictions

Commercial Space



Average equilibrium debris flux at 800 km

* Corrected for Low Earth Orbit (Earth shielding and gravity focusing)

BOEING

Peat Marwick

Debris/Meteoroid Hazard and Dual Plate Shielding System

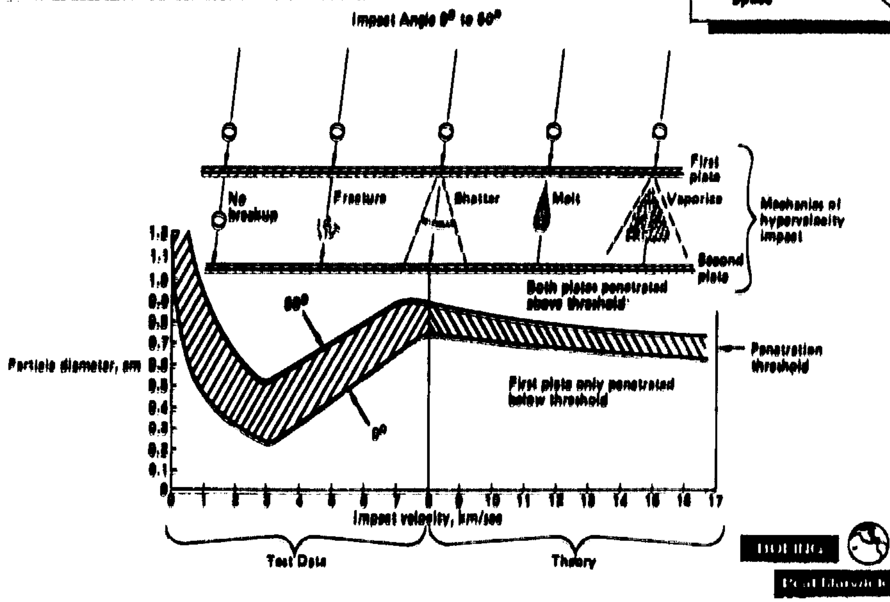
Both natural (meteoroid) and manmade (debris) particles pose a threat to orbiting spacecraft.

> "The possibility that large antimissile spacecraft could be disabled by the billions of particles of manmade debris orbiting the Earth is an area of increasing concern to the Strategic Defense Initiative Organization. This is so because a particle smaller than a grain of sand flying at Mach 25 could destroy an unprotected SDI vehicle. It also could severely damage the U.S./International space station planned for the 1990s. The Air Force is focusing on characterization of the debris hazard and on protection technology. NASA has told outside advisors a safety problem clearly exists."
>
> Aviation Week and Space Technology March 16, 1987

The chart shows the performance of a proposed dual plate shielding system under hypervelocity impact. The most weight efficient shield against meteoroids incorporates at least two separated plates. The first plate is designed to inhibit penetrations in the second by breaking up the particle and spreading out the fragments. The penetration threshold represents the division between penetrating and non-penetrating particles, and is defined with test data and theoretical analysis. Large particles are more penetrating than small particles. Slope changes in the penetration threshold reflect the velocity dependence of hypervelocity impact mechanics; low velocity particles do not break up as much upon first plate impact leaving a more lethal fragment.

The capability of current testing systems limit the test data to below 8 km/s, therefore the penetration threshold above 8 km/s relies on theory. The majority of orbital debris impacts are expected at velocities above current test cabability. The average meteoroid impact velocity is 20 km/s which will vaporize the particle.

Debris/Meteoroid Hazard and Dual Plate Shielding System

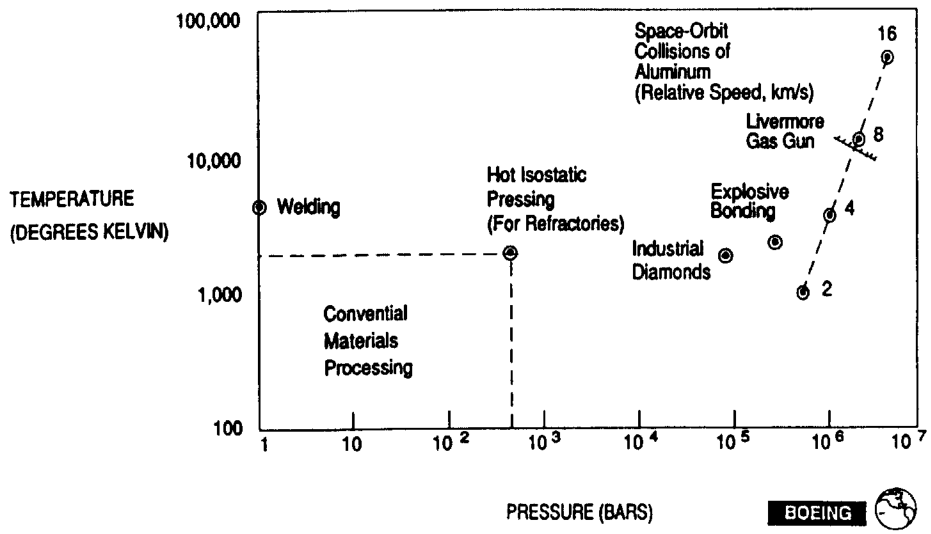


Ultra High-Speed Collisions

Orbital collisions provide a unique test-bed for ultra-high kinetic energy processes. Satellites in low earth orbit travel at 8 km/sec along their trajectories. By counter-orbiting objects (e.g., in polar orbits), a relative collision speed of 16 km/sec can be attained. Such a collision generates exceptionally high pressures and temperatures, well beyond terrestrial processing capability. The experimental light gas gun at Livermore can achieve comparable operating conditions for very minute projectiles. The most energetic high strain rate materials processing is explosive bonding of metals and explosive industrial diamond manufacturing. Possible future applications include processing of refractory or ultra-hard compounds.

Ultra High-Speed Collisions

Commercial Space



BOEING
Peat Marwick

ORIGINAL PAGE IS OF POOR QUALITY

SECTION IV

DOMESTIC AND INTERNATIONAL COMMERCIAL SPACE ACTIVITIES

Domestic and International Commercial Space Activities

October 25, 1988

Frank DiBello
Partner
Peat Marwick Main & Co.

INTRODUCTION

- U.S. competitiveness in the international space market is a major issue facing U.S. industry and NASA.
    - a majority of countries are charting a deliberate path towards becoming self-sufficient in most aspects of civil space activity

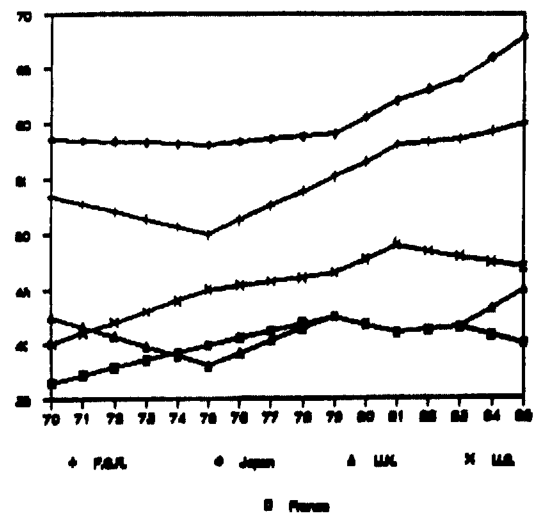
- Present a brief analysis on each major country involved in commercial space adressing observations, technological thrusts and ways of doing business in the following areas:
    - Space Transportation/Launch Services
    - Platforms/Industrial Services
    - Communication Satellites
    - Earth and Ocean Observations
    - Materials Processing in Space

INTERNATIONAL COMMERCIAL SPACE OBSERVATIONS

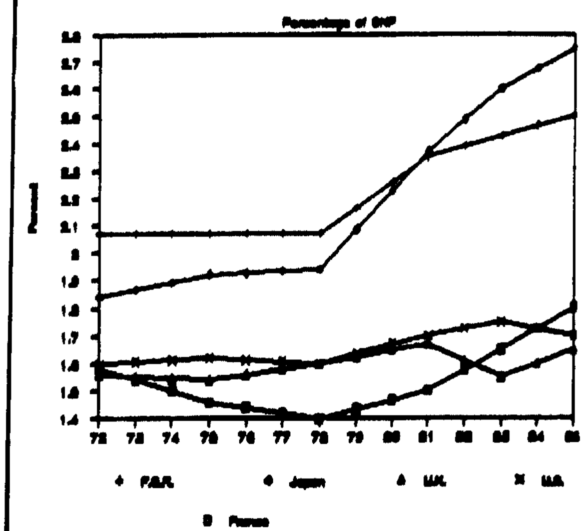
- By mid to late 1990's - Europe, Japan and the Soviet Union will be self-sufficient in most aspects of civil space activities
- There will be more cooperation between governments (Space Station Freedom)
- Teaming and joint ventures are becoming more prevalent in many international space endeavors
- International budgets seem to get more "bang for the buck"
    - smaller government organization
    - more delegation/participation by industry
    - more application focused projects
    - long term planning approach/commitment
    - view space as part of their mainstream economy
- Majority of foreign competition is subsidized

GLOBAL TRENDS

Percent of R&D Funded by Business



Non-Defense R&D Expenditures



GLOBAL TRENDS

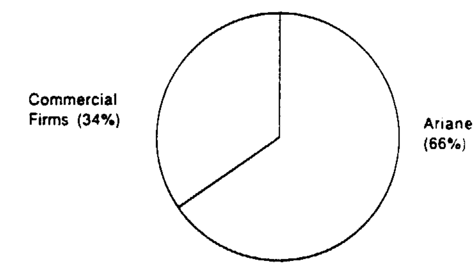
Government Civil Space Applications Budgets*
(Approximate: In millions of then year U.S. Dollars)

Entity	Satellite Communications		Remote Sensing		Materials Processing	
	1983/84	1987	1983/84	1987	1983/84	1987
ESA	222	249	41	198	75	39
France	52	105	92	120	8	14
West Germany	100	30	5	8	22	32
Japan	73	109	66	99	9	14
Canada	33	36	35	43	N/A**	N/A
TOTAL	480	529	239	468	114	99
U.S.A.	32	100	15	24	22	35

* Data for U. K. and Italy unavailable
** Not available

Source: U. S. Civil Space Program: An AIAA Assessment, March 1987, AIAA

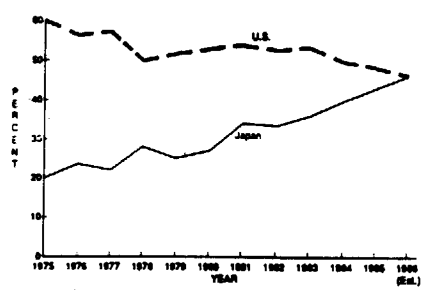
Market Share of U. S. Commercial Firms and Ariane Launch Vehicles, 1989 - 1992



Sources: Office of Commercial Space Transportation, U. S. DOT
Arianespace Launch Manifest, 1988

GLOBAL TRENDS

SHARE OF WORLDWIDE INTEGRATED CIRCUIT SHIPMENTS
(Merchant Producers)



Source: Defense Science Board, Report of the Defense Science Board Task Force on Semiconductor Dependency (Washington, D.C.: GPO, February [illegible]), p. 6.

NO CHOICE BUT FOREIGN CHIPS

GLOBAL POSITIONING SYSTEM (satellites)

INTEGRATED UNDERWATER SURVEILLANCE SYSTEM

DEFENSE SATELLITE COMMUNICATION SYSTEM

FLEET SATELLITE COMMUNICATIONS SYSTEM

SSQ AN-53B SONOBUOY

F-16 FIGHTING FALCON

AIM-7 SPARROW AIR-TO-AIR MISSILE

AM-6988 POET DECOY (expendable jammer)

ARMY HELICOPTER IMPROVEMENT PROGRAM (OH-58 Kiowa)

APG-63 AIRBORNE RADAR (for the F-15 Eagle)

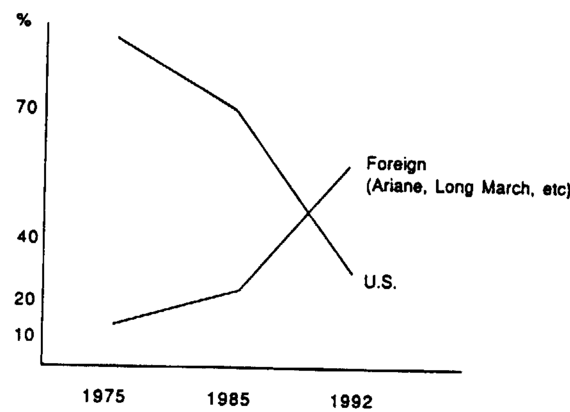
M1 ABRAMS TANK

F/A-18 HORNET

This is a sampling of U.S. military systems containing semiconductors that are available only from foreign sources.

Source: Defense Science Board, Report for the Defense Science Board Task Force on Semiconductor Dependency (Washington, D.C.: Office of the Under Secretary of Defense for Acquisition, February [illegible]), p. [illegible].

Commercial Launch Market Share



ORIGINAL PAGE IS
OF POOR QUALITY

UNITED STATES

Space Transportation	Platforms/Industrial Services	Communication Satellites	Earth and Ocean Observations	Materials Processing In Space
• Space Shuttle- resumed launches 9/29/88 • ELVs - wide range of vehicles - private sector firms have invested over $400m in launch activities - U.S. gov't. is the primary customer - Major suppliers: General Dynamics Martin Marietta McDonnell Douglas	• Space Shuttle - experiment capabilities and satellite deploy, retrieval and repair • Spacelab and Pallets - next launch in 1991 • Space Station • Spacehab • Industrial Space Facility • Free Flyer - long duration exposure facility - SPARTAN - Goddard SFC Explorer Platform Prog. • TDRSS	• Self sustaining commercial industry - thru '83 - 81 satellites sold (72 U.S. built) • ACTS • Domestic satellite paging sytems	• Meteoriogical satellites • Landsat • TOPEX/Poseidon • ERBS - Earth Radiation Budget Satellite • EOS - Earth Observation System • Ground Based Research -sensor development • Two CCDS	• Ground based reseach - NASA centers - use of NASA facilities - 6 CCDS - 3 CE • Space based exp. - electrophoresis - crystal growth - metals & alloys - spacelab exp. - 112 U.S. exp. - 8 JEAs • Space Station - new and extended MPS capability • industry is in research and testing phase

ORIGINAL PAGE IS OF POOR QUALITY

UNITED STATES COMMERICAL SPACE OBSERVATIONS

- U.S. space budget is $28 billion, $10.9 billion is for NASA

<u>Space Transportation</u>

- U.S. faces severe problems from foreign competition and weakening demand for its services
- Ban on shuttle commercial communication launches:
  - was impetus for U.S. ELV industry
  - allowed shuttle manifested payloads to launch with U.S. competitors
- 90% of launches have been successful over past 20 years
- Fiber optics and longer satellite lifetimes will have effect on demand
- Agreement with Chinese on number of U.S. payload launches will be have an effect on this industry
- Small ELV is the fastest growing area (SSS, Pegasus)
  - first Pegasus launch - July 1989
  - new entrants include AMROC, Eprime, Space Services
- Recent launch insurance policy

UNITED STATES COMMERICAL SPACE OBSERVATIONS

Communication Satellites

- U.S. supplies 3/4 of world market
- U.S. satellite manufacturers concerned that other countries will not need American technology to manufacture satellites -- this may open the door for widespread use of Chinese and Soviet launchers
- Sept. 1988 - Dept. of State gave conditional approval for export of two satellites for Aussat and one for AsiaSat

Platforms/Industrial Services

- Industrial Space Facility - man-tended free flyer; on shuttle manifest-1992
- Spacehab - shuttle manifest-1991; NASA agreement for 6 flights
- Astrotech Operations, Inc. - provide payload preparation services at KSC
- Payload System, Inc.
- GE RRS
- GD/Aeritalia joint venture for logistics module and payload processing
- Boeing logistics module proposal

UNITED STATES COMMERICAL SPACE OBSERVATIONS

Commercial Earth & Ocean Observations

- EOSAT Landsat operation
- Landsat 6 approved
- Congress is studying post Landsat 6 requirements
- Increasing number of value added retailers

Materials Processing In Space

- 6 Centers for the Commercial Development of Space (CCDS)
- UAH Sounding Rocket
- Boeing, Rockwell and Grumman furnaces
- Still need more equipment
- 3M is biggest industry participant

European Space Agency (ESA)

Space Transportation	Platforms/Industrial Services	Communication Satellites	Earth and Ocean Observations	Materials Processing in Space
• Ariane 1,2,3 and 4 ELV series • Ariane 5 in development (P) • Hermes - manned reusable spaceplane	• Developed U.S. Spacelab • Partner U.S. Space Station Freedom - develop lab module, polar platform & free flyer • European Retrievable Carrier (EURECA) • Data Relay Satellite System - similar to U.S. TDRSS	• Activity limited to European programs and subcontracting to INTELSAT • 10 year budget of $2.1 billion for space based communication development	• SPOT - commercial system launched 2/86 - 1st of 4 spacecraft - heavily gov't. subsidized - 10m panchromatic data resolution - SPOT Image - commercial firm markets data; founded by CNES	• West Germany & France most active **West Germany** • MPS leader in Europe • Strong gov't. support • Spacelab participation in 1983 and 1985 • TEXUS sounding rocket program (1978) • Pool of hardware for TEXUS and Spacelab • Spacelab D-2 - 1992 • INTOSPACE **France** • Emphasis on ground based research • flew exp. on Spacelab 1 & 3, USSR Salyut & MIR - late 1980's • NOVESPACE

EUROPEAN COMMERICAL SPACE OBSERVATIONS

- Consortium of 13 western European nations with $1.1 billion budget, France supplies 47% of ESA budget

- Highly capable in communication sattellite area, but not yet competitive with U.S. Industry
  - British companies are strongest competitors to U.S. satellite companies
  - Arianespace offered special launch prices to non-european gov'ts. if those customers purchased satellite payloads from Ariane contractors

- Arianespace launched 23 communication satellites over the last 4 years
  - pricing is comparable to U.S.
  - Arianespace has gov't. backing - so could lower price to meet Soviet Proton or Chinese Long March price
  - by 1986, Arianespace had 50% of market; it currently has 60-70% of world market with a backlog of 43 launches
  - Arianespace founded its own insurance company in 1986 when international insurance market was unavailable to insure launch risks

- Ariane vehicle is commercialized thru Arianespace (owned by CNES, aerospace companies and European banks)

- Current MPS leader in the western world
  - Spacelab
  - TEXUS sounding rocket & furnace equipment
  - INTOSPACE, NOVESPACE

JAPAN

Space Transportation	Platforms/Industrial Services	Communication Satellites	Earth and Ocean Observations	Materials Processing in Space
• MU - class launchers • TR-1100 Sounding Rocket • N-I, N-II ELV • H-I - initial launch '87 • H-II (P) • Unmanned mini-shuttle (P)	• Partner U.S. Space Station Freedom • Institute for Unmanned Space Experiments (USEF) Free Flyer (MPS) - (P) • Engineering Test Satellites (P) • Data Relay Satellite System (P)	• Been developing comm. satellites with help from U.S. manufacturers for domestic use • Independent geostationary comm. satellite industry by 1990's (P) • Independent broadcasting satellite industry by 1990's (P) • Major manufacturers are - Nippon Elec. Co. - Mitsubishi Elec. Co. - Toshiba • 1984 - Japan became dominant supplier of large (Class A) ground stations - Japan 41% - U.S. 29%	• MOS-1 - Marine Observation Satellite (1987) • JERS-1 - Earth Resources Satellite - 1992 (P) • GMS series meteorological satellites	• Conducted experiments on Shuttle, Spacelab and its own suborbital rocket • First Materials Processing Test (FMPT) (P) • 5 consortia of Japanese industrial firms organized to pursue space experiments - primarily in microelectronics

JAPANESE COMMERICAL SPACE OBSERVATIONS

- Major thrusts include Space Station Freedom module, launch vehicle, communications and MPS research
- Two space agencies - NASDA (Operations & Applications) & Ministry of Education (Science)
- Dominant planning influence is MITI - thrusts are tied to industry stated needs
- Tension between NASDA and MITI
- Japan will play a significant role in commerical space by mid 1990's
  - goal is to become an autonomous space power
  - gov't. will take the lead and encourage private investment thru: gov't. investment & loans, tax breaks, technology transfer...
- Space budget is $800 million; only $350m below ESA budget which includes 13 member countries
- Expected to invest $5.2 billion on satellite development between 1986 and 2000

USSR

Space Transportation	Platforms/Industrial Services	Communication Satellites	Earth and Ocean Observations	Materials Processing In Space
• Proton ELV • Energia ELV (P) • Kosmolyet - Soviet Shuttle (P)	• Salyut series space stations • MIR Space Station • Glavkosmos marketing microgravity services • Photon Unmanned Recoverable Re-entry Vehicle	• Molniya Spacecraft sytem - 1965 • Intersputnik - 1968 • Geostationary comsats - 1974	• Remote sensing data being sqld worldwide • 4 oceanographic satellites on orbit - KOSMOS 1500 ('83) - KOSMOS 1602 ('84) - KOSMOS 1818 ('87) - KOSMOS 1867 ('87)	• Use Salyut 6,7 and MIR Space Stations • Experiments on semiconductors, crystal growth, life sciences... • Commercial quantities of gallium arsenide and cadmium-mercury-telluride are produced • Developing processing techniques and facilties to support manufacture of advanced materials

USSR COMMERICAL SPACE OBSERVATIONS

- Agressively seeking western customers for its launches and partners for its space projects
- Civil space organization is Glavkosmos - initiated new marketing strategy offering launch capability, pricing flexibility, security of property ...
- Total space budget is $20-25 billion (approx. 75% military) *
- Responsible for 91 out of 103 launches worldwide in 1986; achieved 95 launches in 1987
- March 1988 - conducted commercial launch on Proton ELV for India
  - offer price is approx. 50% of Ariane launch price
- Dept. of State does not allow export licenses for transfer of U.S. built spacecraft to USSR
- Dept. of Commerce granted export license (Feb. '88) to U.S. firm (Payload Systems, Inc.) to allow MPS experiment to be flown aboard MIR
- Achieved over 3000 man hours of experiment time and 1600 experiments to date (MPS) (U.S. has conducted 112 space based MPS experiments)
- MPS program is applications oriented - less emphasis on underlying science

* All budget figures are for 1987-1988 data

CHINA

Space Transportation	Platforms/Industrial Services	Communication Satellites	Earth and Ocean Observations	Materials Processing in Space
• Long March 2,3 ELVs • 1st commercial launch in '87 on LM2 for French co. - MATRA • Launch vehicle technology derived from USSR	• Scientific Exploration and Technical Experimentation Satellite (SETE) - recoverable and non-recoverable MPS capsule - 8/5/88 - launch of West German INTOSPACE commercial payload	• Civil program emphasizes domestic communications, meteorology and earth resources satellites		• SETE - Aug. 1987 was first launch - 2 MATRA exp.

CHINESE COMMERICAL SPACE OBSERVATIONS

- Accelerating its involvement in all areas
- Launched recoverable re-entry satellite August '88 with 4 commercial MPS experiments on board
- Active in world market thru offering of its launch services
  - In negotiations with U.S. Dept. of State to agree upon number of U.S. payloads allowed to be launched aboard Long March vehicle
  - Chinese launching only 4 foreign payloads per year - constitutes 20% of commercial demand thru early 1990's (3 U.S. ELV companies and the French Ariane vie for 15-20 launch demand per year)

OTHER FOREIGN COUNTRIES

Space Transportation	Platforms/Industrial Services	Communication Satellites	Earth and Ocean Observations	Materials Processing In Space
India • SLV-3 • ASLV (P) • PSLV (P) **Brazil** • Sonda series- III & IV	**Canada** • Partner U.S. Space Station Freedom **Germany** • Shuttle Pallet Satellite (SAS) - operates as a free-flyer or in shuttle bay • MAUS - similar to gas can	**Canada** • will be a major competitor in satellite manufacturing industry	**India** • IRS-1 ('88) **Canada** • Radarsat -mid 1990's **Brazil** • Developing 2 earth resources satellites for 1988-1992 launch	

FINAL OBSERVATIONS

- How does the United States compete with a government-sponsored industry that is less dependent on free-market pressure?

- U.S. Industry and the government must recognize the economic benefit of commercial space activities and begin viewing these activities as central to our economic growth and technological leadership!

- It is quite obvious the international countries involved recognize the potential economic benefits derived from commercial space activities, and are charting a deliberate, long term path to exploit this new frontier.

SECTION V

NASA'S CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE

NASA

National Aeronautics and
Space Administration

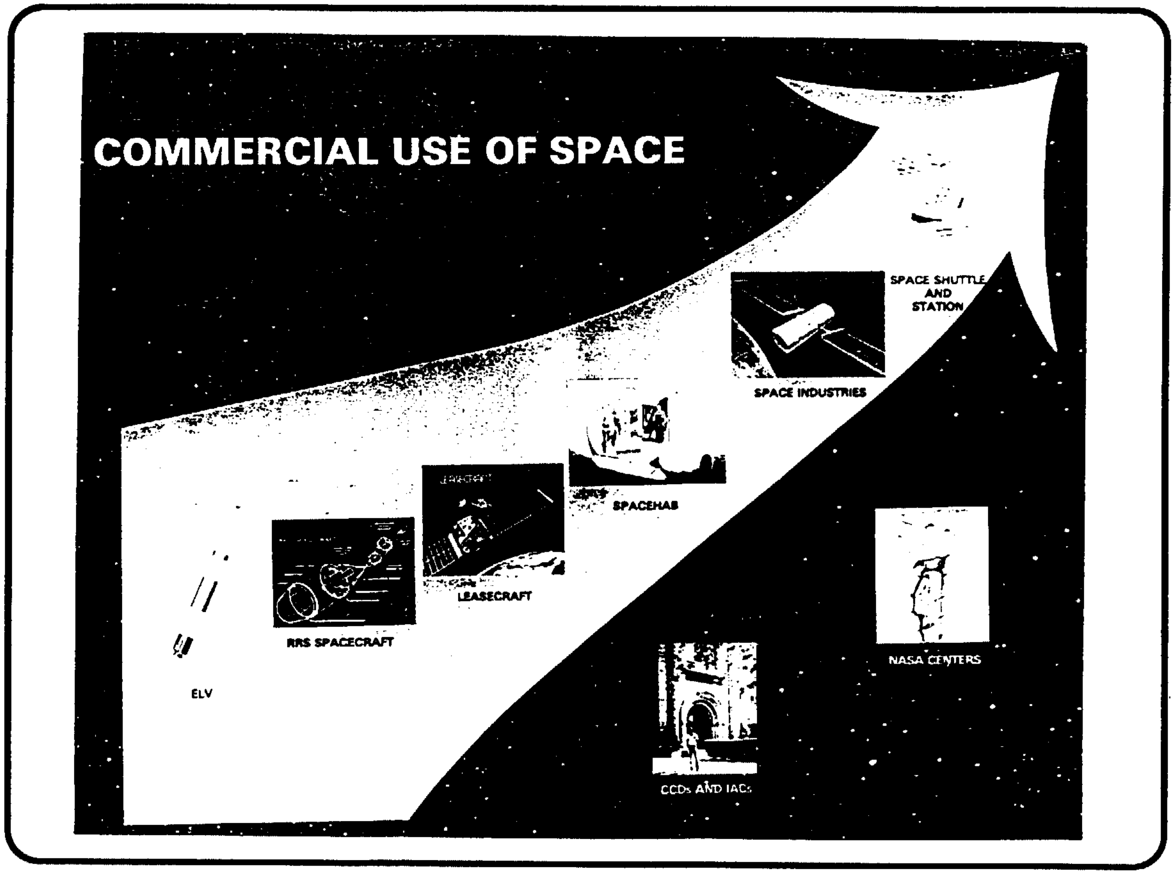
NASA
OFFICE OF COMMERCIAL PROGRAMS
COMMERCIAL DEVELOPMENT DIVISION

CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE

SPACE STATION FREEDOM WORKSHOP

RAYMOND P. WHITTEN
DEPUTY DIRECTOR
COMMERCIAL DEVELOPMENT DIVISION
OFFICE OF COMMERCIAL PROGRAMS

OCTOBER 25, 1988



ORIGINAL PAGE IS
OF POOR QUALITY

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

EXECUTIVE AND LEGISLATIVE BRANCH PRONOUNCEMENTS IN SUPPORT OF COMMERCIAL SPACE

"We will soon implement a number of executive initiatives, develop proposals to ease regulatory constraints, and with NASA's help, promote private sector investment in space."

State of the Union Address, 1984

"In the zero gravity of space, we could manufacture in 30 days life saving medicines it would take 30 years to make on Earth. We can make crystals of exceptional purity to produce super computers, creating jobs, technologies and medical breakthroughs beyond anything we ever dreamed possible."

State of the Union Address, 1985

"The Congress declares that the general welfare of the United States requires that the National Aeronautics and Space Administration seek and encourage to the maximum extent possible, the fullest commercial use of space."

Public Law 98-361, 1984

MAINTAINING AND ENHANCING U.S. LEADERSHIP IN COMMERCIAL SPACE ACTIVITIES

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE OBJECTIVES AND CRITERIA

OBJECTIVE

- PROVIDE THE PATHWAY FOR U.S. INDUSTRY TO DEVELOP LEADERSHIP IN THE COMMERCIAL USE OF SPACE
  - DEVELOPING PROGRAMS THAT FOSTER NEW TECHNOLOGY DEVELOPMENT
  - DEVELOPING PROGRAMS THAT LEAD TO NEW COMMERCIAL PRODUCTS

GENERAL CRITERIA

- NEW AND UNIQUE TECHNOLOGY DEVELOPMENT AND SYSTEMS LEADING TO COMMERCIAL USE OF THE SPACE ENVIRONMENT
- HIGHLY SPECIALIZED UNIVERSITY BASED CENTERS TO HELP U.S. INDUSTRY FOCUS ON TECHNOLOGY DEVELOPMENTS THAT ARE COMMERCIALLY-ORIENTED
- SYSTEMATIC EVOLUTION OF CENTERS TO BECOME HIGHLY INDEPENDENT OF NASA THROUGH THEIR DEVELOPMENT OF INDUSTRIAL COMMITMENT

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE

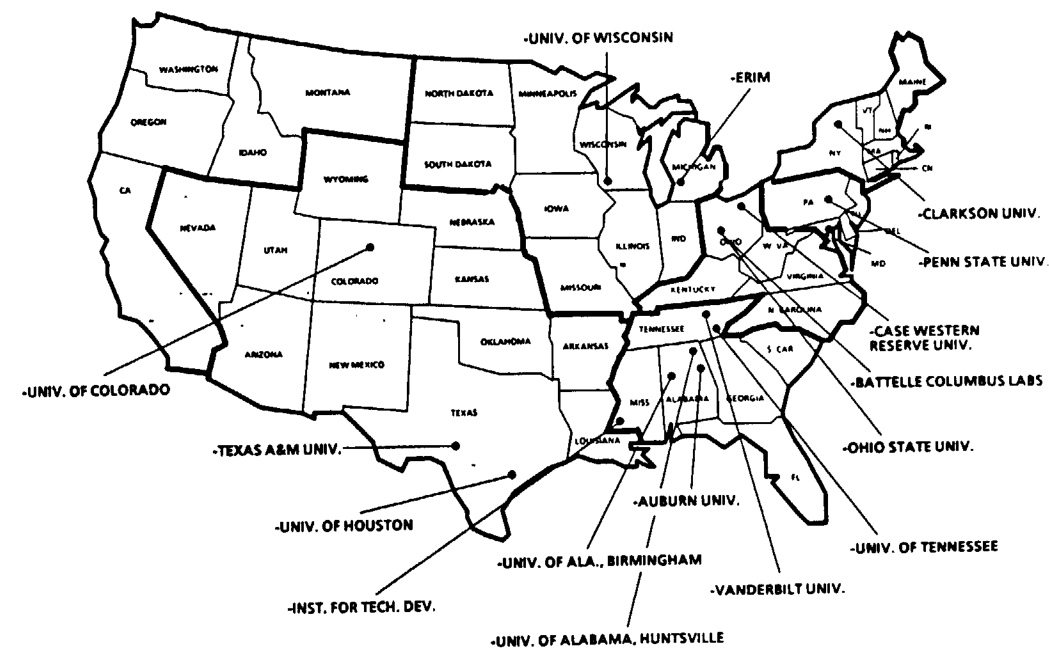
- SINCE 1985, 16 CENTERS FORM THE CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS). THESE CCDS'S ARE EVOLVING TO BECOME AN INTEGRAL PART OF SPACE COMMERCIALIZATION ACTIVITIES.
- RECENTLY, SPECIAL EMPHASIS HAS BEEN PLACED ON THE PROGRAM TO PROVIDE OPEN COMMUNICATION AND A SHARPER FOCUS ON CCDS ACTIVITIES. "ONE-ON-ONE" FULL-DAY MEETINGS WITH EACH CCDS WERE CONDUCTED BETWEEN APRIL 14, 1988, AND JUNE 22, 1988.
- THE "ONE-ON-ONE" SESSIONS HAVE PRODUCED POSITIVE RESULTS, AND HAVE PROVIDED A GOOD OVERVIEW AND FEEDBACK OF THE CCDS AND HEADQUARTERS PROGRAMS.
- A SEPARATE WORKSHOP FORUM WITH ALL NASA FIELD CENTER COMMERCIAL SPACE REPRESENTATIVES WAS HELD ON JUNE 15,1988. THE OBJECTIVE WAS TO DISCUSS THE NEW DIRECTION GIVEN THE CCDS'S, OCP'S CURRENT FOCUS AS IT RELATES TO OUR INVOLVEMENT WITH THE CCDS'S, AND THE FIELD CENTERS CURRENT AND FUTURE RELATIONSHIPS TO SUPPORT THE CCDS PROGRAM.

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

UNIQUE CHARACTERISTICS OF THE CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS) PROGRAM

- INCUBATOR FOR COMMERCIAL SPACE VENTURES
  - -- STIMULATES THE UNIVERSITY/INDUSTRY LINKAGES IN COMMERCIAL SPACE ENTERPRISE
  - -- PROVIDES BREEDING GROUND FOR UNIVERSITY, GOVERNMENT, AND INDUSTRY RISK SHARING WITH ACADEMIA AS THE PULL AND COMMERCIAL NEEDS AS THE PUSH
  - -- PROVIDES FOR CONSORTIA ACTIVITIES OF UNIVERSITIES AND BUSINESSES TO:
    - DEVELOP JOINT CONCEPTS
    - SHARE TECHNOLOGY, COSTS, AND TALENT
    - SHARE RESULTS
  - -- PROVIDES FIRST OPPORTUNITY FOR FOCUSED APPLICATION OF INDUSTRIAL CONCEPTS UNIQUE TO THE SPACE ENVIRONMENT
  - -- PROVIDES SEEDING OPPORTUNITY FOR THRESHOLD INDUSTRIAL RESEARCH PROJECTS
  - -- PROVIDES EASIER ACCESS TO THE SPACE ENVIRONMENT FOR COMMERCIAL EXPERIMENTS
  - -- PROVIDES OPPORTUNITY FOR SMALL BUSINESSES TO LINK UP WITH LARGER BUSINESSES THROUGH CCDS/SMALL BUSINESS INNOVATION RESEARCH/NASA SPONSORSHIP
  - -- ENHANCE THROUGH ACADEMIC TIES THE ABILITY TO ANALYZE FLIGHT EXPERIMENT RESULTS
  - -- PROVIDES BREEDING GROUND FOR 21ST CENTURY SPACE INDUSTRIAL SCIENTISTS

CENTERS FOR COMMERCIAL DEVELOPMENT OF SPACE NATIONWIDE



ORIGINAL PAGE IS OF POOR QUALITY

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS)

TECHNICAL DISCIPLINE	# INVOLVED	CCDS'S
1. AUTOMATION AND ROBOTICS	2	• UNIV. OF WISCONSIN, MADISON, WI • ENVIRON. RESEARCH INST. OF MICHIGAN, ANN ARBOR, MI
2. LIFE SCIENCES	3	• UNIV. OF COLORADO, BOULDER, CO • PENN STATE UNIV., UNIVERSITY PARK, PA • UNIV. OF ALABAMA, BIRMINGHAM, AL
3. MATERIALS PROCESSING IN SPACE (MPS)	5	• BATTELLE, COLUMBUS, OH • UNIV. OF ALABAMA, HUNTSVILLE, AL • VANDERBILT UNIV., NASHVILLE, TN • CLARKSON UNIV., POTSDAM, NY • UNIV. OF HOUSTON, HOUSTON, TX
4. REMOTE SENSING	2	• INST. FOR TECH. DEVELOP., STENNIS SPACE CENTER, MS • OHIO STATE, COLUMBUS, OH
5. SPACE POWER	2	• AUBURN UNIV., AUBURN, AL • TEXAS A&M UNIV., COLLEGE STATION, TX
6. SPACE PROPULSION	1	• UNIV. OF TENNESSEE SPACE INSTITUTE, TULLAHOMA, TN
7. SPACE STRUCTURES AND MATERIALS	1	• CASE WESTERN RESERVE UNIV., CLEVELAND, OH

SUMMARY: THERE ARE CURRENTLY SEVEN TECHNOLOGY DISCIPLINES REPRESENTED IN THE CCDS PROGRAM. THE MAJORITY OF THE CCDS'S ARE CONDUCTING RESEARCH IN MPS.

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE
CURRENT STATUS

- 32 UNIVERSITY PARTICIPANTS
- 119 INDUSTRIAL BUSINESS PARTICIPANTS
- IDENTIFIED 129 PRODUCTS/PRODUCT CATEGORIES
- 615 DROP TUBE/TOWER EXPERIMENTS
- 21 KC-135 FLIGHT EXPERIMENTS
- 1 SERIES OF LEAR JET FLIGHTS
- 4 STS FLIGHTS
- 5 EXPERIMENTS PREPARED FOR FIRST SOUNDING ROCKET FLIGHT
- SMALL BUSINESS PARTICIPATION BEING DEVELOPED FOR SMALL BUSINESS INNOVATION RESEARCH AWARDS

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE
UNIVERSITY AFFILIATES

32 = UNIVERSITIES

AKRON UNIVERSITY	ALABAMA A&M UNIVERSITY
CASE WESTERN RESERVE UNIVERSITY	UNIVERSITY OF FLORIDA
CLARKSON UNIVERSITY	RENSSELAER POLYTECHNIC INSTITUTE
CLEVELAND UNIVERSITY	UNIVERSITY OF ILLINOIS - URBANA
OHIO STATE UNIVERSITY	UNIVERSITY OF WISCONSIN - MADISON
WASHINGTON STATE UNIVERSITY	KANSAS STATE UNIVERSITY
WORCESTER POLYTECHNIC	UNIVERSITY OF UTAH
UNIVERSITY OF MAINE	UNIVERSITY OF COLORADO - DENVER
MURRAY STATE UNIVERSITY	FLORIDA A&M UNIVERSITY
FLORIDA STATE UNIVERSITY	UNIVERSITY OF BUFFALO
MONTANA STATE UNIVERSITY	UNIVERSITY OF SOUTH CAROLINA
UNIVERSITY OF SOUTHERN MISSISSIPPI	TENNESSEE STATE UNIVERSITY
PURDUE UNIVERSITY	AUBURN UNIVERSITY
UNIVERSITY OF ALABAMA - HUNTSVILLE	PRAIRIE VIEW A&M UNIVERSITY
UNIVERSITY OF ALABAMA - TUSCALOOSA	LAMAR UNIVERSITY
UNIVERSITY OF FLORIDA - GAINESVILLE	UNIVERSITY OF TEXAS AT ARLINGTON

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

PRELIMINARY LISTING OF CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE CORPORATE AFFILIATES

119 CORPORATE

AMOCO CHEMICALS CORPORATION
PPG INDUSTRIES, INC.
ROCKWELL INTERNATIONAL
E.I. DuPONT
II-VI, INC.
HERCULES
BOEING AEROSPACE COMPANY
FRONTIER RESEARCH
DEERE AND COMPANY
IBM ALMADEN
MARTIN MARIETTA AEROSPACE
McDONNELL DOUGLAS CORP.
TELEDYNE BROWN ENGINEERING
WYLE LABORATORIES
MASSCOMP
INTERNATIONAL PAPER
SOIL TECH, INC.
EXXON
MURPHY OIL
FREEPORT McMORAN
APPLE COMPUTERS
HARDING LAWSON & ASSOCIATES
PALEN FARMS, INC.
GEOSTAR, INC.
VERSATEC
PIONEER SEED COMPANY
TENNECO OIL COMPANY
BRITISH PETROLEUM
FIRST NATIONAL BANK OF TONKAWA
BANK OF WELLINGTON
ASTRONAUTICS CORP. OF AMERICA
AT&T
SCHERING CORP.
PROCTOR & GAMBLE
DOW CHEMICALS
SMITH, KLINE & BECKMAN
ELI LILY
MERCK, SHARPE & DOME
UPJOHN
EASTMAN KODAK
BIOCRYST
ALCOA
ARMCO, INC.
ALLIED SIGNAL
CABOT, CORP.
ENGLEHARD CORP.
GENERAL ELECTRIC
GENERAL MOTORS
GTE
LOCKHEED
GRUMMAN CORP
TRANS-TEMP
WESTINGHOUSE
DANTEC ELECTRONICS
QUANTUM TECHNOLOGIES
BARNES ENGINEERING
SPACEHAB
SPECTRON LABORATORIES
ELECTRO-OPTEK
PERKIN ELMER
INSTRUMENTS S.A., INC.
BEAVER DAM EMERGING GROWTH
GAMMEX, INC.
DELCO
JOHNSON CONTROLS, INC.
MADISON KIPP, INC.
PHYTO FARMS OF AMERICA
PIERSON PRODUCTS, INC.
SILICON SENSORS
SNAP-ON-TOOLS
SUNDSTRAND CORP.
SEVRAIN TECH, INC.
AMERICAN ELECTRIC POWER COMPANY
TRIMBLE NAVIGATION
GAS RESEARCH INSTITUTE
SYNERCOM, INC.
DEC
3M
GOODYEAR
TRW
EDISON POLYMER INNOVATION
DOVAL COMPOSITES, INC.
LeMONT SCIENTIFIC, COMPANY
COULTER
SUPELCO
SCIENTIFIC SYSTEMS, INC.
ZETACHRON
MONOCLONAL PRODUCTION
DIGENE
SCIENTIFIC ENTERPRISES
ELECTROPORE, INC.
BEND RESEARCH
GELMAN SCIENCES
MICKLEY & ASSOCIATES
PRECISION SCIENTIFIC
BALL AEROSPACE
ALZA
MAXWELL LABORATORIES
ROCKETDYNE
SATURN CORP.
SYMBOLICS, INC.
TECHNION, INC.
PEPCO
GULF STATE UTILITIES
ENTECH, INC.
ARTHUR D. LITTLE
FORD AEROSPACE
SOLAR ENERGY RESEARCH INSTITUTE
ELECTRIC POWER RESEARCH INSTITUTE
COMSAT CORP.
EAGLE PICHER, INC.
E-SYSTEMS, INC.
GENERAL DYNAMICS
ELECTROCHEM , INC.
FAIRCHILD
KMS FUSION
GEOSPECTRA, INC.
DUPERON, INC.
INVITRON

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

UNIVERSITY OF ALABAMA, BIRMINGHAM CENTER FOR MACROMOLECULAR CRYSTALLOGRAPHY

THE UNIVERSITY OF ALABAMA, BIRMINGHAM (UAB) CENTER FOR MACROMOLECULAR CRYSTALLOGRAPHY IS A CENTER FOR COMMERCIAL DEVELOPMENT OF SPACE (CCDS) CONDUCTING RESEARCH IN BIOLOGICAL PROCESSES

<u>PRIMARY OBJECTIVES</u>

- TO FACILITATE ACCESS TO THE SPACE PROGRAM BY AMERICAN INDUSTRY, SPECIFICALLY, PHARMACEUTICAL, CHEMICAL, AND BIOTECHNOLOGY
- TO PURSUE RESEARCH NECESSARY TO FOSTER AREAS OF TECHNOLOGY THAT ARE LIKELY TO BENEFIT FROM SPACE
- TO PROVIDE THE DATA THAT WILL PERMIT INDUSTRY TO EVALUATE POTENTIAL APPLICATIONS OF SPACE (I.E., PROTEIN CRYSTAL GROWTH AND PROTEIN ENGINEERING)

<u>INDUSTRIAL AFFILIATES</u>

MCDONNELL DOUGLAS
DOW
DUPONT
KODAK
BIOCRYST
BURROUGHS-WELLCOME
MERCK
ELI LILLY
SCHERING
SMITH, KLINE & BECKMAN
UPJOHN

<u>UNIVERSITY AFFILIATES</u>

UNIVERSITY OF ALABAMA - HUNTSVILLE

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

UNIVERSITY OF ALABAMA, BIRMINGHAM CENTER FOR MACROMOLECULAR CRYSTALLOGRAPHY (CONTINUED)

AREAS OF CONCENTRATION

- CRYSTAL GROWTH STUDIES IN SPACE AND ON THE GROUND
- PROTEIN STRUCTURAL STUDIES
- DRUG DESIGN BASED UPON PROTEIN STRUCTURE
- HARDWARE AND SOFTWARE SYSTEMS FOR MACROMOLECULAR CRYSTALLOGRAPHY

COMMERCIAL APPLICABILITY

- DEVELOPMENT OF HIGH QUALITY CRYSTALS USED TO DESIGN DRUGS FOR:
  - CANCER
  - AIDS
  - RHEUMATOID ARTHRITIS
  - HIGH BLOOD PRESSURE
  - JUVENILE DIABETES
  - EMPHYSEMA
  - TISSUE TRANSPLANTS

PROGRESS

- DEVELOPED BIOCRYST (SMALL BUSINESS PARTIALLY OWNED BY UAB)
- 2 GRANTS FROM NIH (VALUE $1 MILLION)
- STAFF:
  - 8 POSTDOCTURAL SCIENTISTS
  - 1 RESEARCH ENGINEER
  - 4 Ph.D. STUDENTS
  - 3 RESEARCH TECHNICIANS
- ACCOMPLISHED STS FLIGHTS:
  - STS-51D (APRIL 1985)
  - STS-51F (JULY 1985)
  - STS-61B (NOVEMBER 1985)
  - STS-61C (JANUARY 1986)
- IGI'S INCLUDED ON STS-26:
  - SCHERING CORP.
  - DUPONT
  - MERCK
  - UPJOHN

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

POTENTIAL COMMERCIAL APPLICATIONS FROM CCDS ACTIVITIES

CCDS	PRODUCT/PROJECT CATEGORY/RESEARCH TOPIC
UAH	BLENDED POLYMERS (IMMISCIBLE) AND SEPARATION OF ORGANIC MATERIALS
	POLYMER FOAM FORMATION FOR STRUCTURAL MATERIAL FOR SPACE USE
	IMPROVED SURFACE COATINGS AND METAL CATALYSTS (BY ELECTRODEPOSITION)
	COMPOSITES OF METALS AND REFRACTORY MATERIALS (POWDERED METAL SINTERING)
	IMPROVED CAST IRON PROCESSES
	OPTICAL COMPUTERS AND ELECTRO-OPTICAL DEVICES (HIGHLY NON-LINEAR OPTICAL ORGANIC CRYSTALS AND FILMS)
	IMPROVED DETECTOR MATERIALS (NUCLEAR TRACK DETECTORS)
	SPACECRAFT SURFACE COATINGS (MATERIALS PREPARATION AND LONGEVITY IN HYPERTHERMAL ATOMIC OXYGEN)
	ZINC SELENIDE ELECTRO-OPTICAL DEVICES (CRYSTALS BY VAPOR TRANSPORT)
	HIGH TEMPERATURE SUPERCONDUCTORS WITH APPLICATIONS FOR IMPROVED COMMERCIAL SATELLITES
	PURIFIED MATERIALS USING A WAKE SHIELD
CLARKSON	LIQUID ENCAPSULATED MELT ZONE OF GALLIUM ARSENIDE
	DIRECTIONAL SOLIDIFICATION OF CADMIUM TELLURIDE
	VAPOR GROWTH OF SENSOR MATERIALS
	ZEOLITE PRODUCTION IN SPACE
	SOLUTION GROWTH OF OPTICAL MATERIALS

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

POTENTIAL COMMERCIAL APPLICATIONS FROM CCDS ACTIVITIES (CONTINUED)

CCDS	PRODUCT/PROJECT CATEGORY/RESEARCH TOPIC
PENN STATE	OSTEOCLAST CELL CULTURE; MORPHOLOGY (OSTEOPOROSIS/ACID SECRETION)
	ESTROGEN DELIVERY TO SUSPENDED RAT (OSTEOPOROSIS THERAPY)
	SHEAR STRESS ON BONE CELLS (FLUID SHEAR ON LOADING)
	CHONDROCYTE CELL CULTURE; TIBIAL DYSCHRONDOPLASIA (PARACRINE INTERACTIONS; ANGIOGENESIS)
	GROWTH FACTORS AND MARROW (OSTEOCLAST DEVELOPMENTAL CONTROL)
	GH ON BONE CELLS (GH, OSTEOPOROSIS)
	BOMECHANICS OF HUMAN FOOT (EXERCISE/LOADING - SHOE DESIGN)
	BOMECHANICS/BIOCHEMISTRY OF BONE (OSTEOPOROSIS AND CHANGES IN BIOMECHANICAL PROPERTIES)
	HORMONAL CONTROL OF BONE REMODELING (PREVENT BONE LOSS)
	BONE CELL MORPHOLOGY (GROWTH FACTOR CONTROL)
	RAT CASTING FOR MIMICS OF HUMAN DISEASE (BONE DISEASE IN CHILDREN)
	SUSPENDED RAT (BONE CELL FUNCTION IN MODIFIED FLIGHT)
	RECOMBINANT DNA (EPO PRODUCTION/RECEPTORS; ANEMIA)
	GLOBIN DIFFERENTIATION (EPO CONTROL)
	INTRACELLULAR LOADING/MARKING (RED CELL REMOVAL; ANEMIA)
	MICROCIRCULATION (CONTROL OF DRUG DELIVERY)
	CELLULAR IMMUNOLOGY OF LYMPHOCYTES (LIGHT AND HORMONAL REGULATION OF IMMUNE SYSTEM)
	PITUITARY CELL ISOLATION/FUNCTION (GH/PRL ON IMMUNE SYSTEM)
	PITUITARY CELL FUNCTION/NEUROTRANSMITTERS (AGRICULTURE/PHOTOPERIOD EFFECTS)

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

POTENTIAL COMMERCIAL APPLICATIONS FROM CCDS ACTIVITIES (CONTINUED)

CCDS	PRODUCT/PROJECT CATEGORY/RESEARCH TOPIC
PENN STATE	CELLULAR IMMUNOLOGY
	LIGHT/IMMUNE EFFECTS IN CHICKENS (EFFECTS OF LIGHT ON HEALTH)
	LIGHT AND ARCHITECTURAL DESIGN (EFFECTS OF LIGHT ON HEALTH)
	QUALITY OF LIGHT ON LIVING SYSTEMS (IMPORTANCE OF LIGHT IN SPACE)
	PHOTOPERIOD AND BRAIN ACTIVITY (AGING)
	IMMUNE FUNCTION IN IMMOBILIZED ANIMALS (AUTOIMMUNE DISEASE IN CHILDREN)
	PITUITARY CELL FUNCTION (GH)
	PHOTOPERIOD (JET LAG)
	SHEAR STRESS IN BIOREACTOR (EFFECT ON PRODUCTION OF BIOMOLECULES)
	MICROCALORIMETRY WITH BIOREACTOR (MONITOR CELL METABOLISM IN SPACE; INTERFERON)
	REMOVAL OF TOXIC SUBSTANCES FROM SPENT MEDIA (COST EFFICIENCY OF MEDIA RECYCLING)
	IMAGE ANALYSIS (MONITOR CELL ACTIVITY IN SPACE)
	EXPRESSION OF RGH IN KIDNEY CELLS IN BIOREACTOR (ANCHORAGE DEPENDENT CELLS)
	EXPRESSION OF EPO IN TRANSFECTED CELLS IN REACTOR (ANCHORAGE DEPENDENT CELLS)
	HPLC-DOWNSTREAM PROCESSING (CONVECTIVE FLOW IN S. ACE)
UNIVERSITY OF TENNESSEE	LIQUID STORAGE AND TRANSFER IN ORBIT
	ION PROPULSION
	COMPONENT LIFE MANAGEMENT EXPERT SYSTEM
	EXPERT SYSTEM APPLICATION TO FAULT DIAGNOSIS
	ADVANCED HIGH AREA RATIO NOZZLE
	SPRAY COMBUSTION STABILITY
	MAGNETIC ANNULAR ARC THRUSTER

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

POTENTIAL COMMERCIAL APPLICATIONS FROM CCDS ACTIVITIES (CONTINUED)

CCDS	PRODUCT/PROJECT CATEGORY/RESEARCH TOPIC
CASE WESTERN	ORGANIC COATINGS
	FILMS AND FOAMS
	ORGANIC COMPOSITES
	INORGANIC COMPOSITES
	INORGANIC COATINGS
AUBURN	POWER CONDITIONING
	DISCRETE POWER/ENERGY STORAGE SOURCES
	POWER TRANSMISSION
	POWER SYSTEM SENSORS
	POWER DISTRIBUTION MANAGEMENT AND CONTROL
	POWER SYSTEM PROTOTYPES
	SPACE ENVIRONMENT TESTING
TEXAS A & M	MICROWAVE POWER TRANSMISSION
	TWO-PHASE FLOW IN MICROGRAVITY
	HEAT PIPES FOR MICROELECTRONIC CIRCUITS
	ADVANCED SOLID POLYMER ELECTRODE FUEL CELL OPERATION IN MICROGRAVITY
	PERFORMANCE/LIFE VALIDATION OF CONCENTRATING SOLAR PHOTOVOLTAIC ARRAY

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

POTENTIAL COMMERCIAL APPLICATIONS FROM CCDS ACTIVITIES (CONTINUED)

CCDS	PRODUCT/PROJECT CATEGORY/RESEARCH TOPIC
ITD	SPECTRAL AND SPATIAL DATA SUPPORT SERVICES FOR ARCHAEOLOGICAL APPLICATIONS AERIAL DIGITAL MULTISPECTRAL DATA FOR ENGINEERING APPLICATIONS (E.G., DAMS, DIKES, LEVEES, REFINERIES, CHEMICAL PLANTS, MAPPING SUBSURFACE FIRES, ANALYSES OF WATER RESOURCES, CENTRAL HEATING DISTRIBUTION SURVEYS, GROUND WATER SEEPAGE, POLLUTION STUDIES)
WISCONSIN	TELEROBOTIC SYSTEMS AND COMPONENTS (INCLUDING DEXTEROUS ROBOT HAND, FORCE-REFLECTING FINGER AND GRIPPER, TACTILE FEEDBACK) LUNAR MINING OF He-3 CULTURE AND NUTRIENT SUPPLY SUBSYSTEM FOR PLANT GROWTH FACILITY HUMIDITY CONTROL IN PLANT GROWTH FACILITY
ERIM	DIGITAL IMAGE PROCESSORS 3D LASER RADAR SENSORS SYNTHETIC APERTURE RADAR REMOTE SENSING OPTICAL PROCESSING SYSTEMS INDUSTRIAL ROBOTICS SYSTEMS SPACE ROBOTICS

NASA OFFICE OF COMMERCIAL PROGRAMS

POTENTIAL COMMERCIAL APPLICATIONS FROM CCDS ACTIVITIES (CONTINUED)

CCDS	PRODUCT/PROJECT CATEGORY/RESEARCH TOPIC
COLORADO	ACCELERATED PHARMACEUTICALS TESTING
	BIOPRODUCTS PRODUCTION AND EVALUATION
	ADVANCED FILM AND MEMBRANE TECHNOLOGY
	AGRIGENETICS MATERIALS PRODUCTION
	MODELS OF DISEASE STATES
	MACROMOLECULE SELF ASSEMBLY
	AUTONOMOUS BIOMEDICAL TEST PALLET
	DISUSE OSTEOPOROSIS
	CLOSED ECOLOGICAL LIFE SUPPORT SYSTEM
	SPACE STATION LIFE SCIENCES BAY SIMULATOR
UAB	CRYSTAL GROWTH STUDIES IN SPACE AND ON THE GROUND
	COMPLETE PROTEIN STRUCTURAL STUDIES
	BASIC RESEARCH IN DRUG DESIGN BASED UPON PROTEIN STRUCTURE
	HARDWARE AND SOFTWARE SYSTEMS FOR MACROMOLECULAR CRYSTALLOGRAPHY
	PROTEIN ENGINEERING FROM KNOWLEDGE OF PROTEIN STRUCTURE
	RESEARCH WITH ORDERED MATERIALS
	DEVELOPMENT OF HIGH QUALITY CRYSTALS USED TO DESIGN DRUGS FOR CANCER, AIDS, RHEUMATOID ARTHRITIS, HIGH BLOOD PRESSURE, JUVENILE DIABETES, EMPHYSEMA, AND TISSUE TRANSPLANTS

NASA
OFFICE OF COMMERCIAL PROGRAMS

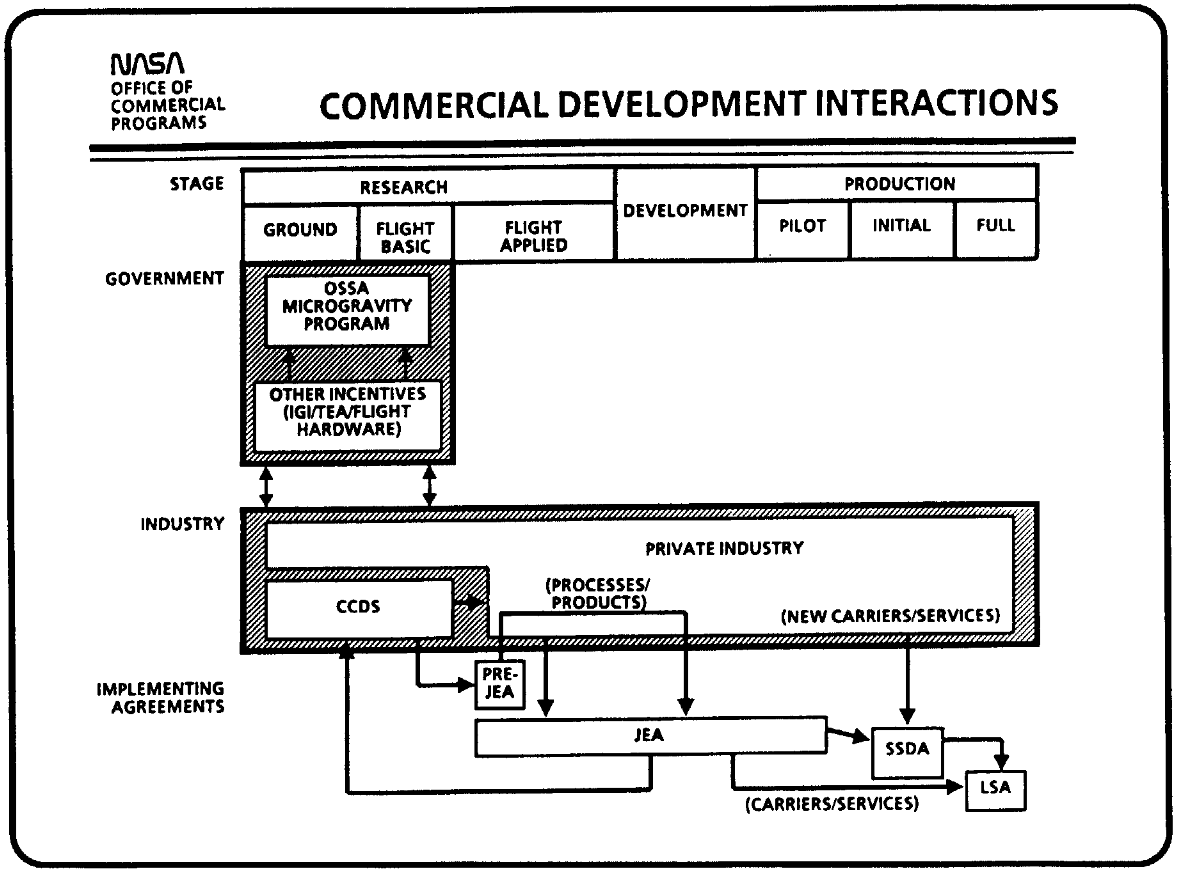
POTENTIAL COMMERCIAL APPLICATIONS FROM CCDS ACTIVITIES (CONTINUED)

CCDS	PRODUCT/PROJECT CATEGORY/RESEARCH TOPIC
BATTELLE	FLOAT-ZONE CRYSTAL GROWTH OF CdTe
	ZEOLITE CRYSTAL GROWTH FOR GASEOUS SEPARATION
	MIXED OXIDE CATALYSTS
	MIXED HALIDE CATALYSTS
	MULTIPHASE POLYMER SYSTEMS
	POLYMER COMPOSITES
	EXTENSION FLOW VISCOSITY
VANDERBILT	DIRECTIONAL SOLIDIFICATION TO OPTIMIZE THE PROPERTIES OF ALUMINUM CASTING AND WROUGHT ALLOYS
	CONTAINERLESS PROCESSING OF TITANIUM-ALUMINUM ALLOYS FOR HIGH TEMPERATURE OPERATIONS
	DEEP UNDERCOOLING OF NICKEL AND IRON ALUMINIDES
	CONTAINERLESS PROCESSING TO IMPROVE THE PURITY AND HOMOGENEITY OF ALLOYS
	IMPROVEMENT OF WORKABILITY OF MATERIALS WITH EXCELLENT RESISTANCE TO CHEMICAL ATTACK
	IMPROVED MAGNET ALLOYS AND THERMOCOUPLE MATERIALS
	TITANIUM/RARE EARTH ALLOYS PROCESSING (FOR FUTURE JET ENGINES)
	CASTING AND DIRECTIONAL SOLIDIFICATION OF IMMISCIBLE ALLOYS (FOR ADVANCED POWER SYSTEMS)
	PRODUCTION OF HOMOGENOUS COMPOSITES CONTAINING FINE STABLE PRECIPITATES
	DEVELOPMENT OF REFRACTORY ALLOYS FOR HIGH-PERFORMANCE POWER SYSTEMS IN SPACE AND AIR APPLICATIONS
	COMPOSITE CERAMICS

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

POTENTIAL COMMERCIAL APPLICATIONS FROM CCDS ACTIVITIES (CONTINUED)

CCDS	PRODUCT/PROJECT CATEGORY/RESEARCH TOPIC
HOUSTON	GROWTH OF GaAs/AlGaAs
	GROWTH OF HIGH Tc SUPERCONDUCTORS
	MOLECULAR BEAM EPITAXY/CHEMICAL BEAM EPITAXY
OHIO STATE	ORBIT DETERMINATION FOR GLOBAL POSITIONING SYSTEM
	IMPROVED OCEAN ROUTING USING REMOTELY-SENSED DATA
	EXTRACTING 3-D INFORMATION FROM AERIAL IMAGERY
	BENEFITS OF AGRICULTURAL LAND DRAINAGE
	SPATIAL DATA DISPLAY
	COASTAL PLANNING
	GAS AND PIPELINE MONITORING
	FEATURE EXTRACTION
	CROP RESIDUE COVER
	TIMBERSTAND EVALUATION
	LAND MANAGEMENT PRACTICES
	SOIL EROSION MONITORING
	REMOTE SENSING FOR MINING OPERATIONS


NASA
OFFICE OF
COMMERCIAL
PROGRAMS
COMMERCIAL DEVELOPMENT INTERACTIONS
STAGE
RESEARCH
GROUND
FLIGHT BASIC
FLIGHT APPLIED
DEVELOPMENT
PRODUCTION
PILOT
INITIAL
FULL
GOVERNMENT
OSSA MICROGRAVITY PROGRAM
OTHER INCENTIVES (IGI/TEA/FLIGHT HARDWARE)
INDUSTRY
PRIVATE INDUSTRY
CCDS
(PROCESSES/ PRODUCTS)
(NEW CARRIERS/SERVICES)
IMPLEMENTING AGREEMENTS
PRE-JEA
JEA
SSDA
LSA
(CARRIERS/SERVICES)

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS) OPERATIONS MANAGEMENT COUNCIL

- PURPOSE

  TO ENHANCE OPERATIONS OF THE CCDS'S, INTERFACE WITH NASA INSTALLATIONS, AND COMMUNICATIONS THROUGHOUT THE STRUCTURE OF THE OFFICE OF COMMERCIAL PROGRAMS (OCP)

- MEMBERSHIP

  -- COMMERCIAL USE OF SPACE REPRESENTATIVE AT EACH FIELD INSTALLATION

  -- DIRECTOR OF EACH CCDS

  -- MEMBERS OF OCP STAFF

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

NEW INITIATIVES FOR 1990

- ESTABLISH TWO NEW CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS)
- MAINTAIN A CADRE OF 18
- PROVIDE ASSISTANCE TO CCDS'S IN FACILITATING AND DEVELOPING CAPABILITIES FOR PRIVATE SECTOR FLIGHT READINESS
- OFFER COMMERCIAL CUSTOMERS ALTERNATIVE MEANS OF FLYING EXPERIMENTS
- ESTABLISH QUICK RESPONSE TO INDUSTRIAL OPPORTUNITIES
- DEVELOP CAPABILITY FOR PRIVATE SECTOR/CCDS COMMERCIAL SPACE FINANCIAL ASSESSMENTS AND PACKAGING
- DEVELOP CAPABILITY FOR AD HOC INFRASTRUCTURE PLANNING AND ADVOCACY

SECTION VI

COOPERATIVE AGREEMENTS AND RESOURCES AVAILABLE TO SUPPORT COMMERCIAL SPACE VENTURES AND PROJECTS

NASA
National Aeronautics and
Space Administration

BRIEFING TO

SPACE STATION FREEDOM WORKSHOP

HYATT REGENCY TECH CENTER
DENVER, COLORADO

HARRY ATKINS
EXECUTIVE ASSISTANT
OFFICE OF COMMERCIAL PROGRAMS

OCTOBER 25, 1988

NASA OFFICE OF COMMERCIAL PROGRAMS

OFFICE OF COMMERCIAL PROGRAMS BRIEFING OUTLINE

- OFFICE OF COMMERCIAL PROGRAMS
  - ORGANIZATION
  - GOALS AND PHILOSOPHY
- SPECTRUM OF PRIVATIZATION/COMMERCIALIZATION ACTIVITIES
- NASA COOPERATIVE AGREEMENTS
- RESOURCES AVAILABLE
  - MICROGRAVITY SCIENCES AND PRODUCT DEVELOPMENT
  - EARTH OBSERVATIONS
  - LIFE SCIENCES
  - ON-ORBIT FACILITIES
    - SHUTTLE
    - SPACE STATION
  - INDUSTRIAL APPLICATION CENTERS
- POINT OF CONTACT

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

OFFICE OF COMMERCIAL PROGRAMS KEY OBJECTIVES

- ESTABLISH A CLOSE WORKING RELATIONSHIP WITH THE PRIVATE SECTOR AND ACADEMIA TO ENCOURAGE INVESTMENT IN, AND THE USE OF, SPACE TECHNOLOGY
- FACILITATE PRIVATE SECTOR SPACE ACTIVITIES THROUGH THE USE OF AVAILABLE GOVERNMENT CAPABILITIES
- ENCOURAGE PRIVATE SECTOR INVESTMENT THAT IS INDEPENDENT OF NASA FUNDING
- ASSURE CONSISTENT NASA-WIDE IMPLEMENTATION OF THE COMMERCIAL SPACE POLICY

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

SPECTRUM OF PRIVATIZATION/ COMMERCIALIZATION ACTIVITIES

TYPE	CHARACTERISTICS	TYPICAL EXAMPLES	PRIVATE CAPITAL AT RISK	BENEFIT TO NATIONAL ECONOMIC GROWTH
PRIVATE SECTOR DEVELOPS FROM EXISTING TECHNOLOGY FOR PRIVATE SECTOR USE	• MATURE INDUSTRY	• COMMUNICATION SATELLITES	MINIMUM	HIGH
PURE PRIVATIZATION	• U.S. GOVERNMENT (USG) DEVELOPS SYSTEM TECHNOLOGY • PRIVATE SECTOR TAKES OVER DEVELOPED TECHNOLOGY	• EXPENDABLE LAUNCH VEHICLES (ELV)	MINIMUM	MINIMUM
PRIVATE SECTOR DEVELOPS FOR USG USE	• USG DEFINES REQUIREMENTS • PRIVATE SECTOR DEVELOPS NEW TECHNOLOGY	• TDRSS • PAM-D • TOS • CDSF	MODERATE	MODERATE
PRIVATE SECTOR DEVELOPS FROM NEW TECHNOLOGY FOR PRIVATE SECTOR USE	• USG DOES BASIC RESEARCH • USG PROVIDES INCENTIVES • PRIVATE SECTOR/USG PARTNERSHIPS (JEA'S, CCDS'S) UNTIL PRIVATE SECTOR IS ESTABLISHED	• PHARMACEUTICALS • CRYSTALS • GEOSTAR	HIGH	EXTREMELY HIGH
FULL COMMERCIALIZATION	• PRIVATE SECTOR DOES R&D DEVELOPMENT, NEW SERVICES/PRODUCTS, ETC. • USG MAY PROVIDE MINIMUM ASSISTANCE THROUGH TRANSPORTATION SUPPORT	• NEW MARKETS, PRODUCTS, AND SERVICES • ELV RAW MATERIALS TRANSPORT	MODERATE	EXTREMELY HIGH

NASA
OFFICE OF COMMERCIAL PROGRAMS

SPECTRUM OF PRIVATIZATION/ COMMERCIALIZATION ACTIVITIES

TYPE	KEY ISSUES	KEY ACTIONS
PRIVATE SECTOR DEVELOPS FROM EXISTING TECHNOLOGY FOR PRIVATE SECTOR USE	• NASA/INDUSTRY TECHNOLOGY ADVANCEMENTS	• COMMUNICATION SATELLITE - CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS) • SPONSOR MORE ACTIVE REMOTE SENSING PROGRAM
PURE PRIVATIZATION	• INSURANCE • INTERNATIONAL COMPETITION	• IDENTIFICATION OF OPPORTUNITIES • FACILITATE • EXPENDABLE LAUNCH VEHICLE AGREEMENTS
PRIVATE SECTOR DEVELOPS FOR U.S. GOVERNMENT USE	• IDENTIFYING OPPORTUNITIES • CONSISTENT POLICIES • PROCUREMENT POLICY WHICH FACILITATES CONTRACTS • COMMERCIALIZATION CRITERIA	• COMMERCIALIZATION POLICY AND CRITERIA • DEVELOPMENT OF FINANCIAL ANALYSIS CAPABILITY
PRIVATE SECTOR DEVELOPS FROM NEW TECHNOLOGY FOR PRIVATE SECTOR USE	• CONSISTENT, ASSURED FUTURE SPACE TRANSPORTATION FOR PRODUCTS/SERVICES DEVELOPMENT • BROAD, FLEXIBLE PRICING POLICIES FOR SHUTTLE AND SPACE STATION • INSURANCE • INTERNATIONAL COMPETITION • NEED BETTER MICROGRAVITY DATA BASE	• DEVELOP FLIGHT PLAN TO MEET REQUIREMENTS • PRICING STUDIES FROM USERS' PERSPECTIVE • MANAGEMENT STRUCTURE TO BRING CCDS'S INTO MAINSTREAM • STREAMLINE AGREEMENT PROCESS • MICROGRAVITY PROGRAM
FULL COMMERCIALIZATION	• DEFINING FULL COMMERCIALIZATION GOALS • PLANNING FOR REALIZATION OF GOALS • INTERNATIONAL COMPETITION	• STRATEGIC PLANNING • COMMERCIAL PROGRAMS ADVISORY COMMITTEE • NEW OPPORTUNITIES FOR SMALL BUSINESS

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

NASA COOPERATIVE AGREEMENTS

- MEMORANDUM OF UNDERSTANDING (MOU)
- TECHNICAL EXCHANGE AGREEMENT (TEA)
- INDUSTRIAL GUEST INVESTIGATOR AGREEMENT (IGI)
- MEMORANDUM OF AGREEMENT (MOA)
- LAUNCH SERVICES AGREEMENTS (LSA)
- SPACE SYSTEMS DEVELOPMENT AGREEMENT (SSDA)
- JOINT ENDEAVOR AGREEMENT (JEA)
- RANGE USE AGREEMENT (RUA)
- CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS)

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

MEMORANDUM OF UNDERSTANDING (MOU)

- TYPICALLY, PRECURSOR TO JEA
- EXPRESSION OF NASA'S INTEREST IN PROPOSED CONCEPT
- NASA'S OBLIGATION TYPICALLY LIMITED TO PROVIDING READILY AVAILABLE INFORMATION:
  - -- AVAILABLE NASA RESOURCES
  - -- NASA REQUIREMENTS/LIMITATIONS REGARDING SHUTTLE PAYLOADS
- USEFULNESS TO FIRM
  - -- RAISING EXTERNAL FINANCING (SMALL FIRMS)
  - -- SELLING CONCEPT TO CORPORATE HQ (LARGER FIRMS)

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

TECHNICAL EXCHANGE AGREEMENT (TEA)

- DESIGNED FOR MPS MICROGRAVITY RESEARCH
  - -- AT MINIMAL EXPENSE
  - -- NOT READY FOR SPACE-FLIGHT EXPERIMENTS
- EXCHANGE OF TECHNICAL INFORMATION ON SUBJECT GROUND-BASED RESEARCH
- NASA DROP TUBES, DROP TOWERS, KC-135 AVAILABLE
- NO NASA RIGHTS IN DATA NEWLY DEVELOPED BY PRIVATE ENTITY UNDER TEA
- NASA HAS FIRST-PUBLICATION RIGHTS FOR NASA-DEVELOPED DATA

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

INDUSTRIAL GUEST INVESTIGATOR AGREEMENT (IGI)

- NASA/INDUSTRY COLLABORATION ON RESEARCH IN SCIENTIFIC AREAS OF MUTUAL INTEREST
- COMPANY RESEARCHER (AT COMPANY EXPENSE) WORKS WITH NASA-SPONSORED PRINCIPAL INVESTIGATOR ON A NASA-FUNDED SPACE FLIGHT EXPERIMENT
- SMALL LEVEL OF COMPANY RESOURCE COMMITMENT

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

MEMORANDUM OF AGREEMENT (MOA)

- TWO MAJOR EXAMPLES:
  - -- SCOTT SCIENCE AND TECHNOLOGY
    - JSC TECHNICAL ASSISTANCE REGARDING SCOTT'S DESIGN AND DEVELOPMENT OF A LIQUID-PROPELLED UPPER STAGE
    - SCOTT TO REIMBURSE NASA FOR TECHNICAL SUPPORT AT NASA'S MARGINAL COST
  - -- SPACE SERVICES, INC.
    - USE OF LAUNCH FACILITIES AND ASSOCIATED SERVICES AT WALLOPS FLIGHT FACILITY TO SUPPORT COMMERCIAL ELV OPERATIONS
    - NASA TO BE REIMBURSED FOR ALL DIRECT COSTS OF SUPPORT
- COMMON THREAD: REIMBURSEMENT FOR ALL DIRECT/MARGINAL NASA COSTS

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

SPACE SYSTEMS DEVELOPMENT AGREEMENT (SSDA)

- LAUNCH SERVICES AGREEMENT WITH SPECIAL PROVISIONS (E.G., DEFERRED PAYMENT SCHEDULE, EXCLUSIVITY)
- FIRST ENTRANT IN NEW INDUSTRY
- INITIAL FLIGHTS OF A NEW SYSTEM CONTEMPLATED TO BEGIN GENERATING REVENUES DURING TERM OF AGREEMENT
- ASSOCIATED WITH DEVELOPMENT OF SPACE HARDWARE INFRASTRUCTURE
- MUST BE POTENTIAL FOR SIGNIFICANT NATIONAL ECONOMIC OR OTHER BENEFITS

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

JOINT ENDEAVOR AGREEMENT (JEA)

- MAJOR RESPONSIBILITIES OF PRIVATE ENTITY
  - -- CONDUCT EXPERIMENTS AND/OR DEVELOP HARDWARE AT COMPANY EXPENSE
  - -- COMMITMENT TO COMMERCIALIZE ANY PROMISING RESULTS DEVELOPED UNDER JEA'S
- MAJOR NASA RESPONSIBILITIES
  - -- PROVIDE SHUTTLE FLIGHTS AND LAUNCH RELATED STANDARD, NONSTANDARD SERVICES (FIRM PAYS FOR OPTIONAL SERVICES AT MARGINAL COST TO NASA OUTSIDE OF JEA)
  - -- PROVIDE NASA TECHNICAL SUPPORT AND USE OF NASA EQUIPMENT, FACILITIES ON A NONINTERFERENCE BASIS
- ALL OBLIGATIONS - GOOD FAITH EFFORTS BASIS ONLY
- NO EXCHANGE OF FUNDS UNDER JEA
- AN ATTEMPT TO SIGNIFICANTLY REDUCE UPFRONT FINANCIAL AND TECHNICAL RISKS OF PRIVATE CAPITAL INVESTMENT IN SPACE-BASED

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

JOINT ENDEAVOR AGREEMENT PARTNERSHIPS

COMPANY	TOTAL TIME ELAPSED OF CORPORATE PROGRAM	PRODUCT	REMARKS
MICROGRAVITY RESEARCH ASSOCIATES	6 YEARS	GALLIUM ARSENIDE AND OTHER SEMICONDUCTOR MATERIAL	DEVELOPMENT OF ELECTRO-EPITAXIAL CRYSTAL GROWTH PROCESS AND HARDWARE
3M	3 YEARS	NEW AND IMPROVED CONSUMER PRODUCTS BASED UPON ORGANIC AND POLYMER RESEARCH	DEVELOPMENT OF 3 POLYMER FURNACES
ROCKWELL	3 YEARS	FLUIDS EXPERIMENT APPARATUS FOR FLOAT ZONE CRYSTAL GROWTH	DEVELOPMENT OF FLOAT ZONE FURNACE
BOEING	3 YEARS	MERCURY CADMIUM TELLURIDE SEMICONDUCTOR MATERIAL	DEVELOPMENT OF CHEMICAL VAPOR TRANSPORT FURNACE
INSTRUMENT TECHNOLOGY ASSOCIATES	4 YEARS	MICROGRAVITY EXPERIMENT SERVICES	STANDARDIZED EXPERIMENTS CARRIER
INTERNATIONAL SPACE CORPORATION	3 1/2 YEARS	GALLIUM ARSENIDE AND OTHER SEMICONDUCTOR MATERIAL	DEVELOPMENT OF DIRECTIONAL SOLIDIFICATION FURNACE
SPACE COMMERCIALIZATION CONSORTIUM (PENDING)	2 YEARS	GALLIUM ARSENIDE AND OTHER SEMICONDUCTOR MATERIAL	DEVELOPMENT OF FLOAT ZONE FURNACE
HONEYWELL (SPERRY) (PENDING)	2 1/2 YEARS	MAGNETIC ISOLATION SYSTEM	ENHANCED MICROGRAVITY ENVIRONMENT
FAIRCHILD	3 YEARS	LEASECRAFT PLATFORM	PROJECT ON HOLD PENDING DEVELOPMENT OF SUFFICIENT MARKET
MDAC	10 YEARS	BIOLOGICAL MATERIALS	MDAC OFFER OF CARGO BAY CARRIER AND ELECTROPHORESIS EQUIPMENT

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

MATERIALS PROCESSING DISCIPLINES

BIOTECHNOLOGY	ELECTRONIC MATERIALS	METALS AND ALLOYS	COMBUSTION	GLASSES/ CERAMICS	POLYMERS
• SEPARATION & PURIFICATION	• COMPOUND SEMI-CONDUCTORS	• DIRECTIONAL SOLIDIFICATION	• FLAME PROPAGATION	• CONTAINERLESS PROCESSES	• DRUG ENCAPSULATION
• PROTEIN CRYSTAL GROWTH	• ISOTHERMAL SOLIDIFICATION	• METAL MATRIX COMPOSITES	• SMOLDERING	• METAL MATRIX COMPOSITES	• POLYMER CRYSTALS
• CELL CULTURING	• DIRECTIONAL SOLIDIFICATION	• MAGNETIC COMPOSITES	• DROPLET BURNING	• UNIQUE GLASSES	• ELECTROOPTIC THIN FILMS
• TISSUE PRESERVATION	• FLOAT ZONE REFINING	• SUPERALLOYS	• FIRE SAFETY/ CONTROL	• METALLIC GLASSES	• MICROSPHERES
	• VAPOR CRYSTAL GROWTH	• IMMISCIBLE ALLOYS	• IGNITION		• MEMBRANES
	• GRADIENT FREEZE PROCESSING	• METAL FOAMS			• CATALYSTS
		• METALLIC GLASSES			

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

GROUND-BASED RESEARCH

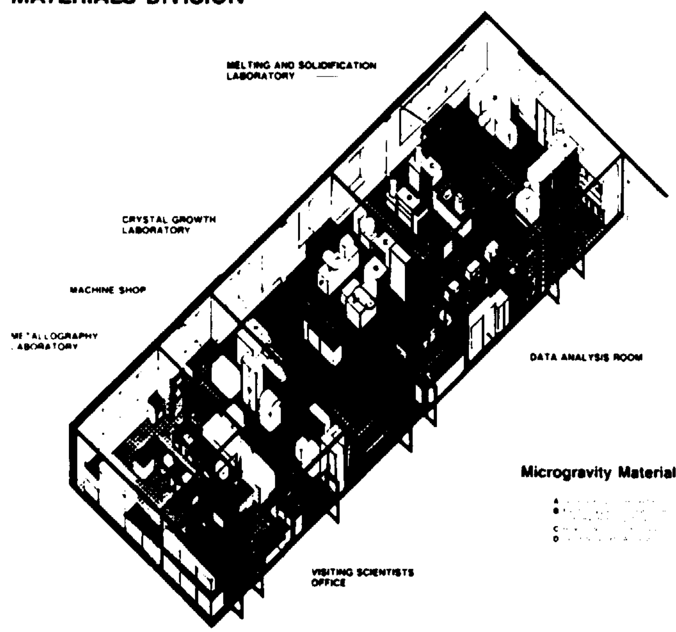
- MARSHALL SPACE FLIGHT CENTER,
  LEWIS RESEARCH CENTER,
  JET PROPULSION LABORATORY

- JOINT EXPERIMENTATION AND USE OF NASA FACILITIES
  LABORATORIES, DROP TUBES/TOWERS, AND
  MICROGRAVITY AIRCRAFT

- TECHNICAL EXCHANGE AGREEMENTS WITH U.S. INDUSTRY

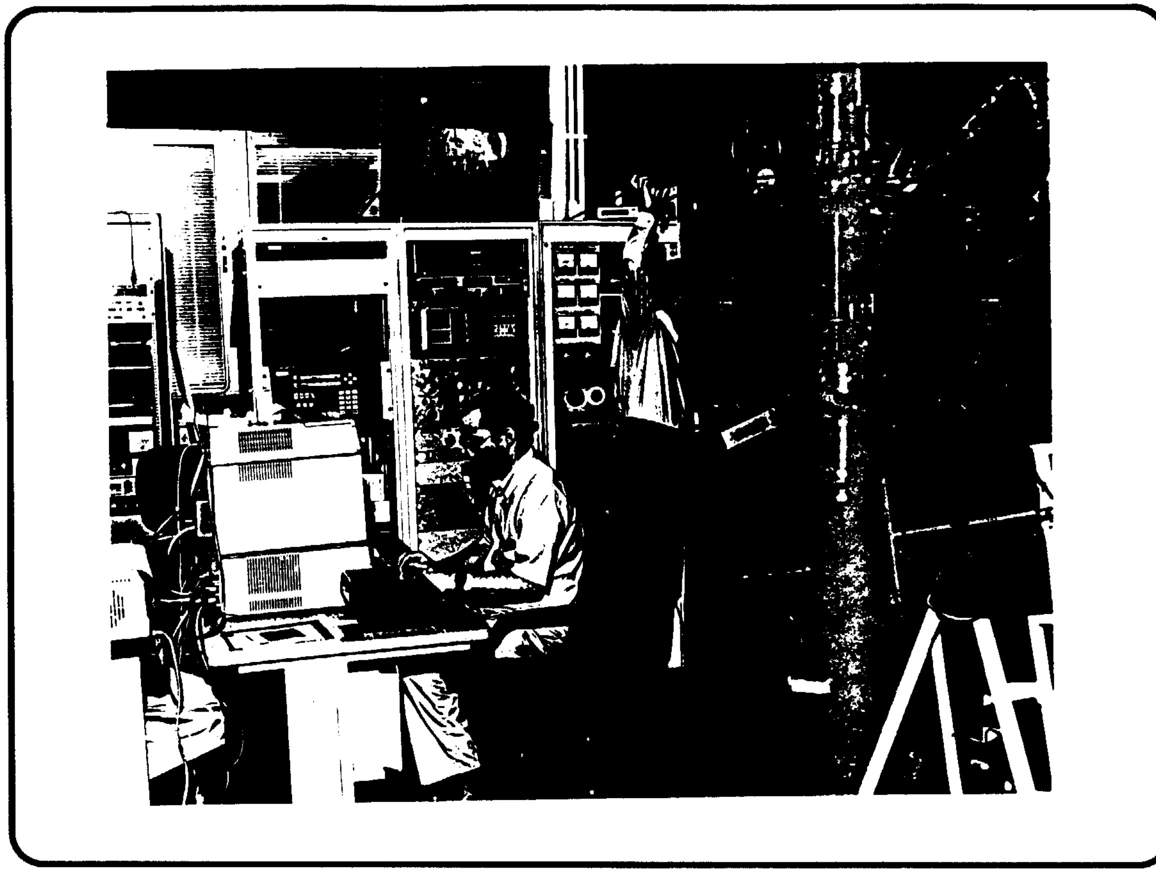
MATERIALS DIVISION

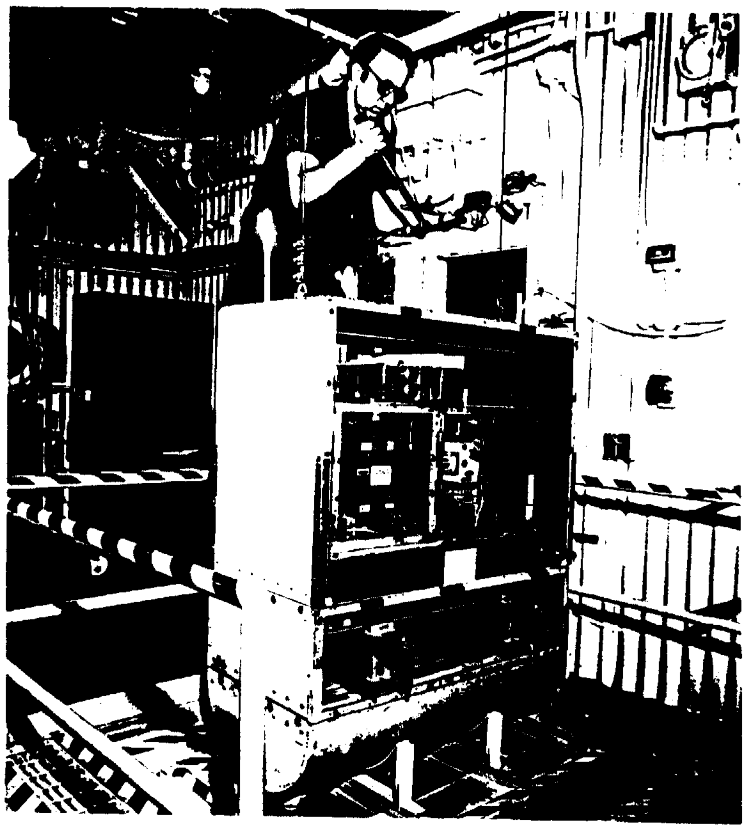
NASA
Lewis Research Center



Microgravity Materials Science Laboratory

ORIGINAL PAGE IS
OF POOR QUALITY

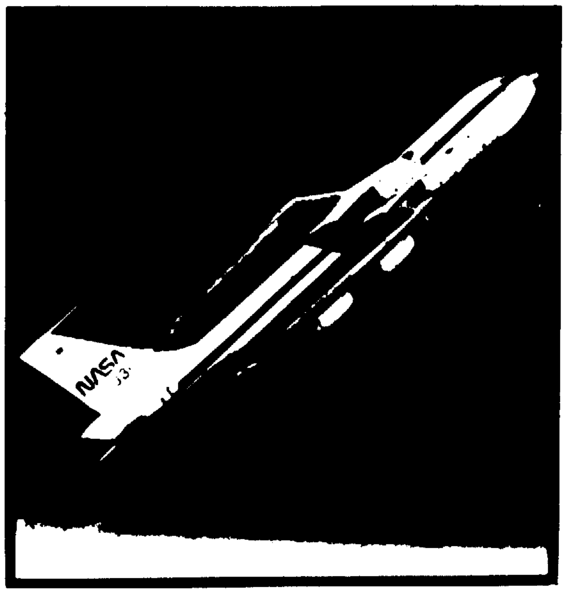




ZERO-G FACILITY

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

LOW-GRAVITY EXPERIMENTATION IN THE KC135



15 - 30 SECONDS LOW G TIME

POWER:	28 V DC		80 AMP
	110 V AC	400 Hz	50 AMP
	110 V AC	60 Hz	25 AMP

LIQUID AND GASEOUS NITROGEN

VENT SYSTEM

MANY PARABOLAS PER FLIGHT

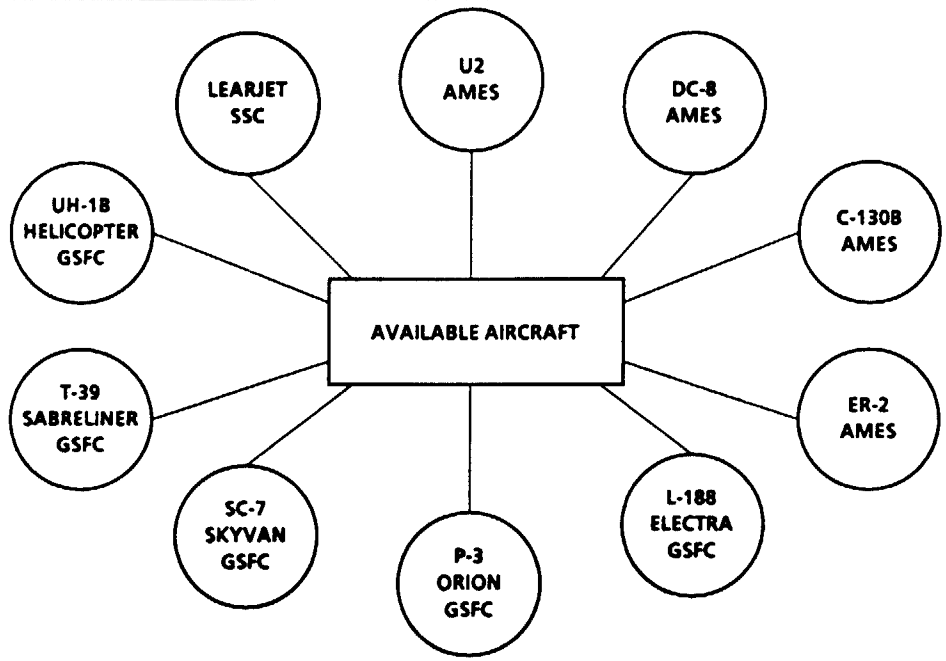
NASA
OFFICE OF
COMMERCIAL
PROGRAMS

CIVILIAN EARTH REMOTE SENSING MISSIONS

- METEOROLOGICAL
- EARTH OBSERVATION
  - -- AGRICULTURE AND FORESTRY
  - -- HYDROLOGY
  - -- GEOLOGY
  - -- LAND USE MAPPING AND PLANNING
  - -- ENVIRONMENTAL MONITORING
  - -- MARINE AND OCEAN RESOURCES
- SEARCH AND RESCUE

NASA OFFICE OF COMMERCIAL PROGRAMS

OFFICE OF COMMERCIAL PROGRAMS
EARTH OBSERVATION PROGRAM



NASA
OFFICE OF
COMMERCIAL
PROGRAMS

FLIGHT PROGRAMS -- RESEARCH AIRCRAFT

- GATES LEARJET

  CENTER : STENNIS SPACE CENTER

  ROLES : GEOLOGY STUDIES
  LAND COVER CLASSIFICATION

  SENSORS: CALIBRATED AIRBORNE MULTISPECTRAL SCANNER (CAMS)
  THERMAL INFRARED MULTISPECTRAL SCANNER (TIMS)

  PERFORMANCE: ALTITUDE : 41,000 FT
  RANGE : 1,000 MI
  DURATION: 3 HRS
  PAYLOAD WT: 750 LBS
  PAYLOAD PWR: 4.0 KW

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

FLIGHT PROGRAMS -- RESEARCH AIRCRAFT

- LOCKHEED U-2

CENTER : AMES RESEARCH CENTER

ROLE : EARTH RESOURCE DATA ACQUISITION

SENSORS: HIGH ALTITUDE MULTISPECTRAL SCANNER
AIRBORNE COASTAL ZONE COLOR SCANNER
AIRBORNE OCEAN COLOR SCANNER
LINEAR ARRAY SCANNER
METRIC CAMERAS
HIGH RESOLUTION PANORAMIC CAMERAS

PERFORMANCE: ALTITUDE : 65,000 FT (CRUISE), 7,000 FT (MAX.)
RANGE : 2,500 NAUTICAL MILES
DURATION: 6.5 HOURS
SPEED : 400 KNOTS TRUE AIR SPEED
PAYLOAD : 750 LBS., Q-BAY; 100 LBS., CANOE; 600 LBS., WING PODS

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

GOALS OF NASA'S LIFE SCIENCES RESEARCH

EXPAND OUR UNDERSTANDING OF THE ORIGIN, EVOLUTION, AND DISTRIBUTION OF LIFE IN THE UNIVERSE

ENSURE THE HEALTH, SAFETY, AND PRODUCTIVITY OF HUMANS IN SPACE

DEVELOP AN UNDERSTANDING OF BASIC BIOLOGICAL PROCESSES OF LIVING SYSTEMS

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

SPACE STATION UTILIZATION

SPACE MEDICINE

- DEVELOP FOUNDATIONS FOR HUMAN HEALTH AND PRODUCTIVITY
- EXPAND THE PHYSIOLOGICAL TOLERANCE LIMITS
- TESTBED FOR FUTURE MISSIONS

GRAVITATIONAL BIOLOGY

- DETERMINE GRAVITY SENSING MECHANISMS OF PLANTS AND ANIMALS
- UNDERSTAND DEVELOPMENT, MATURATION, REPRODUCTION, AND ADAPTABILITY OF PLANTS AND ANIMALS

EXOBIOLOGY

- UTILIZE PLATFORMS FOR THE COLLECTION OF INTERPLANETARY DUST PARTICLES
- USE LABORATORY FACILITIES FOR SAMPLE ANALYSIS AND MODELING STUDIES OF INTERPLANETARY/INTERSTELLAR ENVIRONMENTS

BIOSPHERICS

- USE AS A FACILITY TO STUDY LIFE PROCESSES ON A GLOBAL SCALE (LONG-TERM, CONTINUOUS OBSERVATIONS

PRIVATE SECTOR

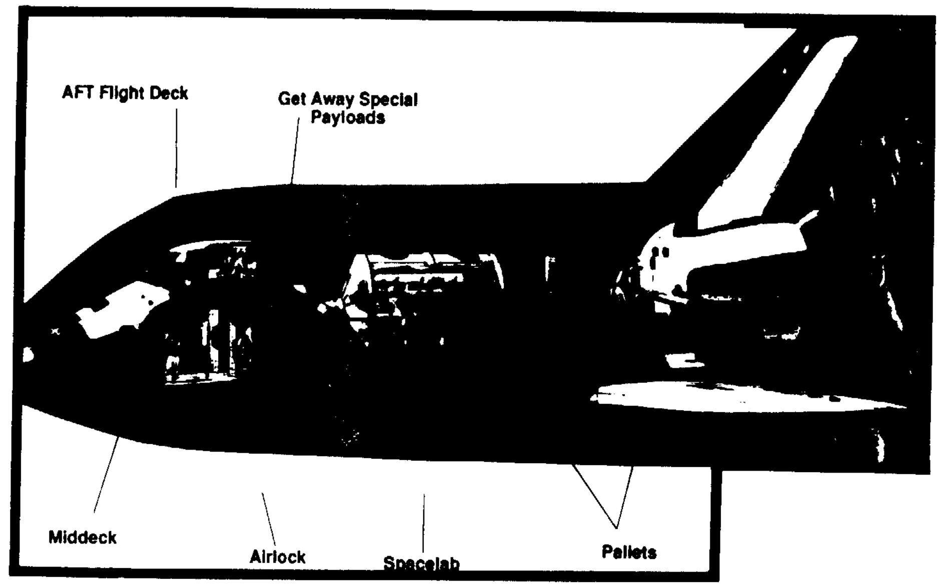
- COMMERCIAL PRODUCTS
- COMMERCIAL SERVICES

CELSS

- DEVELOP BIOREGENERATIVE LIFE SUPPORT SYSTEMS
- OPTIMIZE PLANT GROWTH TECHNIQUES
- EXPAND STAY TIME IN SPACE

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

THE ORBITER CAPABILITIES



NASA
OFFICE OF
COMMERCIAL
PROGRAMS

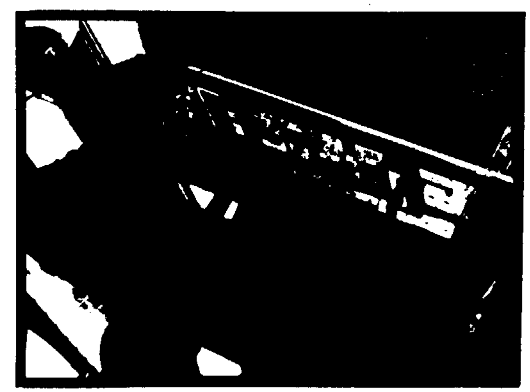
MDAC ELECTROPHORESIS OPERATIONS IN SPACE

ORIGINAL PAGE IS
OF POOR QUALITY

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

ON-ORBIT SERVICES: SPACE STATION

- NASA PROJECT
- DEVELOP A PERMANENTLY MANNED SPACE STATION BY MID 1990'S
- ENHANCE SPACE SCIENCE AND APPLICATIONS
- HELP REALIZE THE COMMERCIAL POTENTIAL OF SPACE
- SECURE INTERNATIONAL COOPERATION
- PROVIDE USEFUL AND AFFORDABLE CAPABILITIES



ARTIST'S CONCEPTION OF
SPACE STATION BY BOEING

NASA
OFFICE OF
COMMERCIAL
PROGRAMS

POINTS OF CONTACT

MPS

THOMAS K. GLASGOW
DIRECTOR
MICROGRAVITY MATERIALS SCIENCE LABORATORY
MAIL STOP 105-1
NASA LEWIS RESEARCH CENTER
21000 BROOKPARK ROAD
CLEVELAND, OH 44135
(216) 433-5013

DR. ROBERT NAUMANN
DIRECTOR
LOW GRAVITY SCIENCE LABORATORY
NASA
MARSHALL SPACE FLIGHT CENTER, AL 35812
(205) 544-7755

ROBERT SCHMITZ
DEPUTY DIRECTOR
MICROGRAVITY SCIENCE AND APPLICATIONS
NASA CODE EN
600 MARYLAND AVENUE, S.W.
WASHINGTON, D.C. 20546
(202) 453-1490

RAYMOND P. WHITTEN
DEPUTY DIRECTOR
COMMERCIAL DEVELOPMENT DIVISION
NASA CODE CC
600 INDEPENDENCE AVENUE, S.W.
WASHINGTON, D.C. 20546
(202) 453-1890

CRAIG VOORHEES
NATIONAL ACCOUNT MANAGER
BOEING/PEAT MARWICK COMMERCIAL USES OF SPACE
600 MARYLAND AVENUE, S.W., SUITE 455
WASHINGTON, D.C. 20024
(202) 479-4240

EOS

DAVID P. BRANNON
CHIEF
COMMERCIAL PROGRAMS BRANCH
NASA HA-31, BUILDING 1100
STENNIS SPACE CENTER, MS 39529
(601) 688-2042

EOS -- CONTINUED

DR. SHELBY TILFORD
DIRECTOR
EARTH SCIENCE AND APPLICATIONS DIVISION
NASA CODE EE
600 INDEPENDENCE AVENUE, S.W.
WASHINGTON, D.C. 20546
(202) 453-1706

RAYMOND P. WHITTEN
DEPUTY DIRECTOR
COMMERCIAL DEVELOPMENT DIVISION
NASA CODE CC
600 INDEPENDENCE AVENUE, S.W.
WASHINGTON, D.C. 20546
(202) 453-1890

DR. ALLEN FEDER
NATIONAL ACCOUNT MANAGER
BOEING/PEAT MARWICK COMMERCIAL USES OF SPACE
600 MARYLAND AVENUE, S.W., SUITE 455
WASHINGTON, D.C. 20024
(202) 479-4240

LS

LAURANCE MILOV
DIRECTOR
COMMERCIAL LIFE SCIENCES WORKING GROUP
AMES RESEARCH CENTER
MAIL CODE 204-10
MOFFETT FIELD, CA 94035
(425) 694-4044

STEVE FOGLEMAN
DEPUTY DIRECTOR
LIFE SCIENCES DIVISION
NASA CODE EB
600 INDEPENDENCE AVENUE, S.W.
WASHINGTON, D.C. 20546
(202) 453-1350

RAYMOND P. WHITTEN
DEPUTY DIRECTOR
COMMERCIAL DEVELOPMENT DIVISION
NASA CODE CC
600 INDEPENDENCE AVENUE, S.W.
WASHINGTON, D.C. 20546
(202) 453-1890

LS -- CONTINUED

ROBERT SCHICK
MANAGER
BOEING/PEAT MARWICK COMMERCIAL USES OF SPACE
600 MARYLAND AVENUE, S.W., SUITE 455
WASHINGTON, D.C. 20024
(202) 479-4240

AGREEMENTS

JACK YADVISH
CHIEF
COMMERCIAL AGREEMENTS BRANCH
NASA CODE CC
600 INDEPENDENCE AVENUE, S.W.
WASHINGTON, D.C. 20546
(202) 453-2103

TECHNOLOGY UTILIZATION

HENRY CLARKS
DIRECTOR
TECHNOLOGY UTILIZATION DIVISION
NASA CODE CU
600 INDEPENDENCE AVENUE, S.W.
WASHINGTON, D.C. 20546
(202) 453-8722

SBIR

HARRY JOHNSON
DIRECTOR
SMALL BUSINESS INNOVATION RESEARCH
NASA CODE CR
600 INDEPENDENCE AVENUE, S.W.
WASHINGTON, D.C. 20546
(202) 453-8341

USER DEVELOPMENT

JOSEPH G. RUTTER
DIRECTOR
BOEING/PEAT MARWICK COMMERCIAL USES OF SPACE
600 MARYLAND AVENUE, S.W., SUITE 455
WASHINGTON, D.C. 20024
(202) 479-4240